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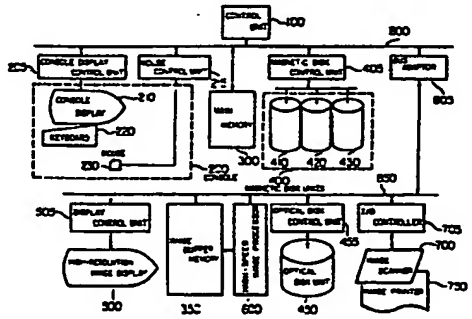
(54) System for information storage and retrieval.

(57) A system for storing a large amount of heterogeneous information in proper arrangement for facilitating utilization thereof by user, while allowing semantical retrieval to be realized even from vague fragmental information. The system can find application in document filing system for storing and managing documents, intelligent card management systems for storing and managing cards such as memorandum cards, or personal data base required for handling heterogeneous information. A method of expressing the facts constituting information in terms of «concepts» representing things and «relations» defined between the concepts internally of computer, and a method of inputting user's information to computer through dialogical procedure and retrieving desired information. Information stored internally of the computer architects internally a concept network. A part of the concept network is displayed in various forms such as hierarchical form based on subsumption relations between the concepts, hierarchical representation based on part-whole relation between the concept, a frame display of a single concept, and tabular representation of a set of concepts belonging to a given class. A method of browsing internally of the network by referring to the contents of the display. The user can thus easily know what kind of information has been stored internally of the computer, whereby he or she can perform inputting of new information and retrieval of desired information in facilitated and simplified manner. The relations stored internally of the computer are classified into «generic relationship» and «instance relation» representing individual facts, whereby generic framework of facts can be stored. The framework can be applied to concrete concepts through inheritance mechanism. The generic framework is displayed upon interaction with the user for allowing new information to be inputted and desired information to be retrieved in a facilitated and simplified manner. Retrieval by using semantic retrieval formula created internally through dialogical procedure is realized through inferring processing.



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SYSTEM FOR INFORMATION STORAGE AND RETRIEVAL

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to an information storage and retrieval system which permits storage, retrieval and display of such information as documents, drawings, photographs and the like in such a manner in which common users can easily manipulate the system for the storage and/or retrieval of information.

DESCRIPTION OF THE PRIOR ART

Heretofore, management of a data base which permits storage and retrieval of an enomous amount of information has been relied on those skilled in the art. The information is available to the end user only through the medium of experts. However, in accompaniment to the development of small size storage device of a large capacity such as optical disk, there are realized document filing systems for office use which can be directly manipulated by the end users. Further, word processors increasingly come into wide use. Under the circumstances, there is an increasing tendency that a large amount of documents are stored in electronic devices.

Heretofore, the items such as documents are managed in tabular form listing bibliographic data such as identification names, titles and author's names attached to the documents, while attempt is made to facilitate the

retrieval of information by assigning keywords or classification codes thereto. Nevertheless, there arise problems mentioned below.

In most of the computer file systems, the file management is performed with the aid of identification names (each composed of ca. 20 characters). However, difficulty is often encountered in naming the document or file so that it can be readily recalled. Besides, searching the file on the basis of the character string which constitutes the name while inferring the contents from the name is an extremely difficult job even for the user who has prepared the name himself.

Since the bibliographic data are objective items, registration thereof can be easily made. However, there scarcely arises the situation in which the bibliographic data are made use of as means for retrieval. Utilization of the bibliographic data as the aid for the retrieval is restricted to the rare case in which the document to be retrieved is clearly known to the user as the source or reference literature.

In most cases of the retrieval of documents, the title ambigously memorized by user or the contents thereof provides a clue for the retrieval. To this end, keywords and classification codes are employed. However, difficulty is encountered already in assigning the keywords or classification codes to the documents upon registration thereof. In other words, it is difficult to determine the keyword which make it possible to retrieve properly the

associated document later on. By way of example, it is assumed that many keywords are attached to a document so that it can be retrieved, as viewed from the various angles. This however means that a number of keywords which are useless for retrieval are employed. If the number of the keywords is decreased, uncertainty arises as to about the correct selection for retrieval. In the data base for literatures, preparation and allocation of the keywords have heretofore been relied on those skilled in the art.

Moreover, difficulty is often encountered in recalling the keyword itself. By way of example, upon preparation of the retrieval formula composed of the keywords for the retrieval of document, literatures having a resemblance to the desired one are searched out from a general list for picking up their keywords, which are then referred to for determining the keywords possibly allocated to the desired document. Such procedure is not rare and tells how difficult it is to recall the keyword.

In the case of filing documents through classification, ambiguousness of the taxonomic tree (hierarcal tree) as well as comfusion of the taxonomic trees (i.e. multiple classifications of one document) provide problem. Besides, standards for the classification vary in the course of time lapse. A span of several years will make the classification standards useless, giving rise to another problem.

Under the circumstance, easy management and

retrieval of information for the user provide extremely important problems remaining to be solved in the hitherto known document filing system.

As an attempt to cope with the above problems, there has been proposed a method of diagraming the retrieval conditions and deriving formal query formula for the retrieval by using natural language, as disclosed in J.F. Sowa's "Conceptual graphs for a Data Base Interface" IBM J. Research and Development, Vol. 20, 1976, p.p. 336-357. Furthermore, a method of assisting creation of the conditional formula for retrieval by presenting knowledge concerning the contents of a data base from computer is known, as disclosed in F.N. Tou et al's "RABBIT : An Intelligent Detabase Assistant", Proceedings of National Conference of AAAI, 1982, p.p. 314-318. These methods are intended only for assisting the retrieval from the data base. No teachings are disclosed as to the assistence of storage of information for the updating purpose.

In the filing of documents by the end user, registration of new document as well as maintenance of the file system (e.g. reexamination as to pertinency of classification) is important for realizing the facilitated retrieval. The approaches mentioned above do not meet this requirement.

Finally, the retrieval is accompanied by still another problem. Namely, no measures are available for re-examining the old information from the view point of a new concept which has not yet been clearly difined at the

time the old information was stored or for retrieving from the new point of view. By way of example, there often occurs such case in which classification is to be modified from the new viewpoint or in a manner specific to the user himself after lapse of several years. In this way, possibility of rearrangement of information as well as alteration of retrieval also provide important factors for enhancing the easy usability of the information storage and retrieval system.

SUMMARY OF THE INVENTION

An object of the invention is to solve the problems mentioned above and provide an information storage and retrieval system which allows the user to retrieve the desired document from ambiguous or vague and fragmentary (partial) information in a facilitated and simplified manner while making it easy to enter or register documents and other information.

In view of the above and other objects which will be more apparent as description procedes, there is provided according to a general aspect of the invention an information storage system in which mechanism of storing information in the machine is so arranged as to compatible or comparable to the man's memorization mechanism and thinking process so that the end user can easily understand manipulation of the system to thereby enhance the facilitated usability thereof.

More specifically, the invention contemplates to

make it possible to facilitate registration of new information and the inputting of conditions for retrieval, realizing semantically meaningful retrieval, and adapting the retrieval for diversity of viewpoints.

To this end, the system according to the invention is imparted with novel functions mentioned below:

(1) Supporting function for registration

For registration of new documents, it is necessary to input the subject matter and the nature or class thereof in addition to the entry of the bibliographic items (author's name, title, the sources and others). Further in order to realize semantic retrieval, it is required to additionally provide more detailed or concrete information. By way of example, suppose that the subject matter is a computer. Then, there may be required such information as "what kind of computer it is", "what characteristics it has", "what company has developed it", "where the company is located", "which country the location belongs to", and so forth. When the information mentioned above is stored, it is possible to retrieve with the aid of inference function "the document concerning a computer developed by a certain company located in a country A and having characteristic features B".

According to the teaching of the invention, knowledge about the concepts "computer", "company" and others is stored in the storage system, wherein upon addition of new information, user is given instruction as to what kind of property data should be inputted through

dialogical procedure, so that he or she can input the data within a short time without being accompanied with entry of erroneous or false information.

In the case where information or similar property has been already registered, such function is realized which allows only the property differing from that of the above information to be inputted without need for entering all the property data of information to be newly inputted, to thereby facilitate the inputting procedure. By way of example, suppose a case in which a man named "John Smith" has been already registered and his brother named "Gorge Smith" is to be newly registered. In that case, by selecting "John Smith" as a similar concept, the system displays a list of the properties of this concept, for example, in a manner as follows:

(FATHER-IS "Davise Smith")
(MOTHER-IS "Samanser Smith")
(BIRTHDAY-IS "May 4, 1960")
(SEX-IS "male")
(HOBBY-IS "music") (1)

Then, the user can input the properties of the concept "Jeorge Smith" that differ from the above, e.g. (BIRTHDAY-IS "June 7, 1963") and (HOBBY-IS "sport").

(2) Supporting Function for retrieval condition input

When the end user is going to perform the retrieval of a document, it is common that he or she has only an ambiguous image or concept of the document and feels difficulty in expressing it in the natural language.

According to the teaching of the present invention, the retrieval is started from the most important concept and information is sequentially added through dialogical procedure or interaction. To this end, the knowledge of the world model conserving the content of the filed documents is stored in the system as is the case with the registration assistence function. On the basis of the knowledge, the names of properties which can be inputted and the concept (class of things) to which the properties may belong are presented to the user.

By way of example, suppose that what the user wants is "technical paper". Then, the user inputs "technical paper". The system knows that "technical paper" has properties such as "author", "title", "subject matter" and others. Accordingly, the system displays on a terminal CRT sets of names of such properties and concepts such as (author, name), (title, text) and (subject, concept). The user who observes the display in turn inputs the selected data which the user memorizes as the relevant information. For example, "subject" is selected and "computer" is inputted. This process can be recursively repeated. In the above example, when the "computer" is inputted as the selected subject, the system in turn displays (DEVELOPED-BY ORGANIZATION COMPANY), (RUNS COMPUTER-LANGUAGE), (RUNS-UNDER OS) and others. In response thereto, the user will input (RUNS LISP) as the additional condition for retrieval.

By virtue of the assistence function mentioned above, there can be established the retrieval condition

as follows:

"Technical paper about computer in which LISP runs and which is written by an employee of a company A"

.... (2)

As will be described in detail hereinafter, the above retrieval condition is expressed in the formula or expression as follows:

```
(TECHNICAL-PAPER
  (SUBJECT-IS
    (COMPUTER (RUNS LISP))
  (AUTHOR-IS
    (EMPLOYEE (WORDS-AT COMPANY A)))) ..... (3)
```

The above expression is based on symbolic expression (S-expression) in LISP Language (refer to P.H. Winston "LISP" Addison-Wesley Publishing Co., 1981, p. 18).

(3) Semantic retrieval function

It is common that a user who wants to retrieve a certain item has only fragmentary and ambiguous information thereof. On the other hand, the computer memory (e.g. data base) stores that item in a definitely concrete name. The gap between the user's fragmentary information and the precise data stored in the computer memory must be pridged.

In this connection, the ambiguity may be generally classified into five varieties mentioned below:

(i) Incompleteness of name

Only a part of the name of an item or concept is memorized.

(ii) Synonym

The same thing is often memorized or recalled in terms of different words. By way of example, words "artificial intelligence", "thinking machine", and "AI" indicates the same concept.

(iii) Incompleteness of number

It is rare that a man remembers numerical values precisely, as exemplified by "during the generation of 1980s", "about 1985", "from 1983 to 1987", "before 1960" and so on.

(iv) Taxonomic conceptual abstraction - 1

Things and concepts are often memorized in terms of concepts of higher rank with the concrete contents being forgotten. Memorization of the concept of higher rank is often based on the clustering, as exemplified by sayings that "although the name of the company is forgotten, the organization is neither university nor laboratory but a company at any rate", "that was a certain electric machinery manufacturer" or the like.

In this case, assuming that the electric machinery manufacturer is "ABC Co., Ltd.", for example, the following relations hold true.

("ABC Co., Ltd." IS-A ELECTRIC-MANUFACTURER)

(ELECTRIC-MANUFACTURER IS-A ENTERPRISE)

Schematically, the concepts "ABC Co., Ltd." and "ELECTRIC-MANUFACTURER" are coupled by a link "IS-A". Herein, the link "IS-A" represents a relationship defined between the two concepts mentioned above and is referred to as the subsumption relationship.

In general, it is believed that all the concepts can be hierarchically classified by means of the link "IS-A". The resulting hierachical tree is referred to as concept tree or conceptual tree.

(v) Partomic conceptual abstraction - 2

The abstraction discussed above is a sort of set theoretical abstraction. It should be pointed out that man often memorizes a thing in terms of upper rank part in part-whole relation of a concept. For example, man says that "although I can not remember the factory where Mr. A works, I am sure that he is an employee of ABC Co., Ltd." or "although I can not remember what the city is called, I am sure that the city is located in the California state".

In contrast, the data base stores the corresponding facts in more definite manner such as "Mr. A works at XYZ factory" or "ABC Co., Ltd., is located at LosAngeles". Accordingly, the information stored in the data base can not be retrieved starting from the ambiguous information memorized in the user.

In this case, the following relation plays an important role.

("ABC Co., Ltd." HAS-PART-OF "XYZ factory")

("California state" HAS-PART-OF "LosAngeles")

what is important to be noted is not

("LosAngeles" IS-A "California state")

but

(LosAngeles IS-PART-OF "California state")

This relation should be clearly distinguished from the

subsumption relation described above. Parenthetically, it should be mentioned that the relation "IS-PART-OF" is a reverse relation of "HAS-PART-OF".

In more strict sense, the relation having directivity such as "IS-PART-OF" and "HAS-PART-OF" is referred to, simply as the relation, while the relation having the directivity lost (and serving only as the link) is referred to as the relationship. In the case of the above example, the relations "IS-PART-OF" and "HAS-PART-OF" are referred to as "part-whole relationship".

As to the man's memorization faculty or characteristic, it may further be pointed out that relation between the concepts is more susceptible to be memorized than the concepts themselves. For example, in the case of retrieval starting from such fragmentary ambiguous information that "the subject matter of a certain article is an operating system which was developed by an institute in U.S.A.", the fact "developed" is important, and this fact represents "relation" defined between the two concepts "operating system" and "institute". In more concrete, retrieval condition may be expressed as follows:

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("UX OPERATING SYSTEM"
    IS-DEVELOPED-BY
        "INSTITUTE B")
```

wherein "IS-DEVELOPED-BY" represents the relation. In the retrieval based on the ambiguous information, this "relation" is important.

Among the characteristics of man's memorizing

faculty, the incompleteness of name and numerical values are taken into consideration in the hitherto known information retrieval. For example, there can be mentioned the matching function of fragmentary (partial) character string and designation of numerical range.

The semantic retrieval function according to the invention is characterized above all by the conceptual abstractions among the classified varieties described above. More specifically, with the aid of the retrieval condition input supporting function, the semantically ambiguous retrieval is rendered possible, as follows:

Retrieval Condition: "Articel concerning a computer developed by a certain company located in California state and in which an operating system developed by a certain institute runs" (4)

In the above conditional statement, the concrete concept is only "California state". Other words which may possibly be used as keywords are "computer", "institute", and "operating system". Through the hitherto known information retrieval system, e.g. keyword retrieval system, any satisfactory results of retrieval can not be obtained.

It is however noted that the conditional statement (4) is considered as "semantic meaningful retrieval condition" according to the invention, because the statement (4) contains relations between "California state"

and "company", "company" and "computer", and "operating system" and "computer", respectively, as the information for retrieval. Further, in the sense that "company", "computer", "operating system" are generic name (abstract concepts), the so-called "abstract" retrieval is realized. In contrast, in the case of the hitherto known retrieval system, since the relations between keywords are not stated, the above statement (4) may be erroneously interpretted as "article about computer introduced by an institute located in California state and in which operating system developed by a certain company runs", which is of course "semantically meaningless retrieval".

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing a system arrangement according to an embodiment of the present invention;

Fig. 2 is a view for illustrating a concept network;

Fig. 3 is a view illustrating the concept network in a schematic diagram;

Fig. 4 is a view showing a concept relation model in a Entity-Relation diagram;

Figs. 5 to 8 are views illustrating concrete examples of knowledge representation by the concept relation model;

Fig. 9 is a view illustrating an example of image data management;

Fig. 10 is a functional block diagram showing

software employed according to an embodiment of the invention;

Fig. 11 is a view for illustrating as a result of character substring matching procedure;

Fig. 12 is a view showing a menu;

Fig. 13 is a view for illustrating network traverse procedure based on selection from the menu;

Fig. 14 is a view showing a concept tree display;

Fig. 15 is a view showing a hierarcal tree based on the part-whole relationship;

Fig. 16 is a view for illustrating network traverse procedure based on concept frames;

Fig. 17 is a view for illustrating method for definition and registration of new concept;

Fig. 18 is a view for illustrating concept network edition;

Figs. 19 to 22 are views for illustrating dialogical retrieval formula creating procedure;

Fig. 23 is a view for illustrating semantic retrieval;

Fig. 24 is a view for illustrating concept matching procedure; and

Fig. 25 is a view for illustrating functions for displaying concepts in tabular form.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, the present invention will be described in detail in conjunction with the exemplary or

preferred embodiments thereof by referring to the accompanying drawings.

Fig. 1 shows a general arrangement of an image information filing system in which an information storage and retrieval system according to an exemplary embodiment of the invention is adopted. In the first place, structure and operation of the whole system will be outlined below.

Basically, the system is composed of a data processing portion and an image information processing portion. The data processing portion comprises a control unit (also referred to as CPU) 100, a main memory 300, magnetic disk units 400 and a terminal console 200 (which includes a CRT 210, a keyboard 220 and a mouse 230) and an image information processing portion. On the other hand, the image information processing portion comprises an image scanner 700, an image printer 750, an optical disk unit 450, an image buffer memory 350, a high-speed image processor (also referred to as IP) 600 and a high-resolution image display (also referred to as CRT) 500. The data processing portion and the image information processing portion are interconnected through a bus adapter 805.

As main operations to be performed, there can be mentioned registration of image information from documents, retrieval of desired information for display or other type of outputting thereof, and inputting and editing of information or data belonging to the field to be filed. In the registration of the image knowledge of document, the latter is scanned through the image scanner 700, wherein

the resulting image information is loaded in the image buffer memory 350 and stored in the optical disk unit 450 after having been coded in a compressed form by the high-speed image processor or IP 600. At that time, the image information in the buffer memory 350 is displayed on the image display or CRT 500 to check whether the image information has been properly digitized, while bibliographic data of the document (such as subject or title, author, the source and others) as well as significance thereof in the world knowledge are inputted through the terminal console 200. The bibliographic data, physical addresses (pack address, track address and sector address) of the image information in concern on the optical disk unit 450 and properties of the image (size, scan density, type of coding as adopted and the like) are stored in the magnetic disk unit or file unit 420. On the other hand, information about the significance of the document in the world knowledge and the like is stored in the file unit 430.

In the retrieval and display operation, the desired document is identified with the aid of the terminal console 200 through dialogical interacting process described hereinafter to be thereby displayed on the image display CRT 500. When a hard copy is desired, this can be outputted from the printer 750. Information about the location of the identified document (such as physical address of the optical disk unit) is read out from the file unit 420 to be subsequently sent to the optical disk control unit 450 as the control command for reading the optical disk by

way of the bus adapter 805. The image information or data thus read out is once stored in the buffer memory 350 and is sequentically decoded through the IP 600 to be displayed.

The mouse 230 is capable of designating the display position or location on both the CRTs 210 and 500. Accordingly, the display position of the image on the CRT 500 is designated by the mouse 230. By taking advantage of this function, the document images on plurality of pages can also be displayed at given locations or positions on the CRT in overlapping relation. Furthermore, the document image corresponding to one page can be displayed in a shrinked size through the IP 600, for thereby allowing a number of pages to be simultaneously displayed on a single CRT screen. Management of images to be displayed on the CRT is performed by the control unit or CPU 100.

Input the edition of the world knowledge are performed on the terminal 200 by displaying the document on the CRT 500, as it is required. With the phrase "world knowledge", it is intended to mean a set of the concepts concerning the world or field described in the document and the facts described in terms of relationships among the concepts, which document is to be registered or has already been registered. Further, the term "world knowledge" encompasses the concepts as well as the inter-conceptural relationships expressed in a natural language. Needless to say, the document itself is included as one of the concepts by the term "world". These knowledges are stored in the file unit 430.

The three main functions described above can be arbitrarily called in a modeless manner whenever they are required. By way of example, information as required can be displayed on the CRT 500 by resorting to the retrieval function in the course of performing the additional edition of the world knowledges. It is also possible to additionally file the knowledge of the contents of a document in the course of performing the registration of the same document.

Next, discussion will be directed to the representation format of the world knowledge data. The representation of knowledge is made in terms of two varieties of elements, i.e. the concepts and the relation(s) between or among the concepts. Fig. 2 is a schematic diagram illustrating conceptually these elements in terms of a kind of a semantic network. In the figure, each node represented by an ellipse represents a concept, wherein the word written within the ellipse is typical one representing that concept. This word is referred to as the name of the concept. Links interconnecting the ellipses (i.e. solid and broken lines with respective arrows) represent the relationships among the concepts. For example, the fact that a "supercomputer 1012" is "one variety of" a "computer 1011" is represented by a link labbelled "IS-A". Hereat, it should be mentioned that "UNIVERSAL 1010" is a specific concept defined to subsume all the other concepts. In other words, all the concepts constitute a concept tree having a root constituted by the

concept "UNIVERSAL", wherein the concept tree represents a taxonomic hierarchy. The link "IS-A" is one variety of the relationships. However, this link also serves as a route for inheriping the property of a concept to the one ranked lower. Consequently, this link or relationship is considered discriminatively from the other relationships. To this end, the links "IS-A" are represented by the arrowed solid lines, while other links or relationships are represented by broken lines.

By way of example, suppose a generic property that "computer runs software". It will be noted that this property can also be represented by the expression "software runs on computer". This kind of relationship will herein be referred to as the generic relationship. The representing format of the generic relationship in the case of the example mentioned above is

(COMPUTER RUNS SOFTWARE)

(SOFTWARE RUNS-ON COMPUTER) ..... (5)

These generic relationships can be taken over to the low rank concepts in such a manner that "supercomputer runs software" and "X-computer runs software" or "operating system runs on computer" and "UX runs on computer". These relationships can be derived from the generic relationship (5) and is not directly described in the knowledge base.

In Fig. 2, the link 1005 interconnecting the concepts "X-800" and "UX" differs from the aforementioned generic relationship. This link 1005 represents the

individual relation defined between the two concepts linked together. This sort of relation will be referred to as the instance relation on simply as relation. It should however be noted that the relation 1005 is an instance relation of the generic relationship 1005.

In this way, the schematic diagram of Fig. 2 tells a fact that the subject matter of an article "ART # 018" denoted by a numeral 1018 is the supercomputer X-800 and that an operating system UX runs on the supercomputer X-800. Further, it will be seen that all the concepts are interconnected by longitudinal lines referred to as the links labbelled "IS-A" on one hand and interconnected by transverse links referred to as the generic relationship and the instance relations, to thereby constitutes the conceptual network.

In this conjunction, it is important to note that the property pertaining to a concept is not only considered from the standpoint of that concept but also equally considered in view of the concept that makes appearance in the definition of the property itself. This can be accomplished by adopting the idea "relation or relationship" defined between the two concepts and by giving a means to see the relation form both of these concepts. By way of example, assuming that the article "ART # 018" whose subject is "X-800" is registered. Then, this means that the fact "X-800" is described in the article ART # 018" is also registered.

The knowledge representation elucidated above can

be formally illustrated such as shown in Fig. 3. From the figure, it will be seen that the system stores four types of data in terms of the concept C, the subsumption relation S, the generic relationship R and the instance relation r for management. More specifically, C(i) represents the i-th concept, S(k, i) represents the fact that a concept C(K) is one variety of the concept C(i), R(m) represents the m-th generic relationship, and r (m, k, ℓ) represents an instance relation of the generic relationship R(m) which is defined between the concepts C(k) and C(ℓ).

More particularly, these four types of data can be represented as an entity relation model in a tabular form, as will be seen in Fig. 4. Referring to the figure, the concept C and the generic relationship R are apprehended to be the entity while the subsumption relation S and the instance relation r are understood to be the relations interlinking the entities. The generic relationship defines a class of the instance relations r and is considered to be the entity. More concrete representations are shown in Figs. 5 to 8 in the form of table.

More specifically, Fig. 5 shows a table which lists up definitions of words representing the concepts. Basically, the table is composed of a column containing identification numbers C# assigned individually to the concepts, a column containing concept names (words or notations) CNAME expressing the concepts, and a column containing indications as to whether the expressions are

primary or secondary ones. For example, the concept identified by the number #58 is "computer" which is also expressed in Japanese.

Fig. 6 shows a table defining the subsumption relations. The table is composed of a column listing the individual concept identification number C# and a column containing the identification number each assigned to a higher rank or superclass concept subsuming the corresponding or associated concept C#. As a special case, the superclass concept of the concept "UNIVERSAL" is defined to be "UNIVERSAL".

Fig. 7 shows a table defining the generic relationships R. The table contains a column listing the numbers RS# identifying the generic relationships, a column listing the relationship names RSNAME of the generic relationships, a column listing readings LR which correspond to the readings of the generic relationships from left to right and a column listing readings RL which correspond to the readings of the generic relationships from right to left. In this conjunction, it is to be noted that "reading from left to right" applies valid only in the basic form in which two concepts interlinked by the associated generic relationship are juxtaposed side by side, the basic form being defined by the instance relation r which will be elucidated by referring to Fig. 8. By way of example, in the table R shown in Fig. 7, the name column RSNAME contains "SUBJECT" as the sixteenth generic relationship. This means that the "SUBJECT" is used as the instance

relations:

IS-SUBJECT-OF

or

SUBJECT-IS

It should further be added that there are such generic relationships for which the same readings are defined to have different meanings or usages. By way of example, there exist in the table of Fig. 7 two same readings "HAS-PART-OF" which however apply to the different generic relationships named "PART-WHOLE 1" and "PART-WHOLE 2". This means that the part-whole relationship for the different concepts is to be handled discriminatively. Suppose for example the relation of "PART-WHOLE 1" to concept "organization". Then, the relationship "PART-WHOLE 1" can be used, for example, in the form:

("ABC Co., Ltd." HAS-PART-OF "XYZ factory") (6)

On the other hand, when the relationship "PART-WHOLE 2" is applied to the concept "DISTRICT", the following relation, for example, applies valid.

("California state" HAS-PART-OF "LosAngeles") (7)

Fig. 8 shows a table containing the relations r defined between the concepts. In this table, both the generic relationships and the instance relations are entered. A column G/I serves to discriminates the generic relationship and the instance relation, wherein G indicates the generic relationship with I indicating the instance relation.

In the table r shown in Fig. 8, the records

include the relation identifying number R#, the generic relationship identifying number RS# indicative of the type of the relationships, the left concept identification number CL identifying the concept located on the left side in the basic form, and the right concept identification number CR identifying the concept located on the righthand side in the basic form.

By way of example, the relation #4 is a generic relationship (G/I = G) which is defined by the concept #58 ("computer") and the concept #64 ("software") and which has meaning defined by the generic relationship #7. More specifically, in the table r, the following two relations in appearance

(computer RUNS software)

(software RUNS-ON computer) (8)

are represented by the single record. Similarly, the relation #724 is an instance relation of the generic relationship #7 and interlinks the concepts #1512 and #1051 with each other. Namely, as will be seen in the table C, relations mentioned below are represented.

(X-800 RUNS UX)

(UX RUNS-ON X-800) (9)

Four kinds of data (tables C, S, R and r) described above are stored in the file 430 as the knowledge base.

Next, a table D for defining document images will be described with reference to Fig. 9. The table 9 includes columns for the document indentification number D#, concept

identification number C#, document size SIZE, compressing code type CODE, image scanning density DENS, physical address PHYSA on the optical disk and the number of recording sectors LENG. In the case of the record illustrated in Fig. 9, it will be seen that the document #98 concerns the concept #313 (i.e. article ART #018, see Fig. 5), the size is A4, the scanning is effected at the density of 16 lines/mm, the compressing code is the MH code, and that the document is stored at 13 sectors following the address "400207" inclusive, of the optical disk.

As will be apparent, it is possible to combine all the concepts with respective document image. This means that the concept "COMPUTER", for example, may be accompanied with the illustrative image of "DOCUMENT", if desired. Further, a single concept may be annexed with a plurality of different documents.

The table D is stored for management in the file 420 shown in Fig. 1.

In the foregoing, description has been made on the structure of the apparatus and the data representation formats embodying the invention. In the following, description will be directed to a software structure and processing procedures. Fig. 10 illustrates the software structure. In the first place, it should be mentioned that the illustrated software is processed by the control unit 100 (Fig. 1) and programs as required are stored in the file 410 (Fig. 1).

Referring to Fig. 10, the software includes a

dialogue control module 2001, a search and concept matching module 2001, a query formula generation module 2003, a concept network editor 2004, a network traverse control module 2005, a table manipulation module 2006, and an image display control module 2010.

Description will first be made on the function of the table manipulation module 2006 which constitutes one of the basic components. In table manipulation module 2006 serves for manipulation of data of the aforementioned various table formate at a level of high order as well as retrieval of the data. Main functions will be enumerated below. Parenthetically, it should be mentioned that the program is written in LISP language and that S-expression is adopted. Further, for facilitation of the description, variables and functions are represented by small letters while constants are represented by capital letters.

As a function for creating a new table, "create-table" function can be mentioned. As to the table R shown in Fig. 7, for example, the framework thereof can be newly defined by calling the above function as follows:

```
(create-table 'R
              '(RS # RSNAME LR RL))        (10)
```

wherein the first argument is the name of the table and the second argument represents the list (set) of the columns' names, while the quotation mark "!" means that the symbol following the mark is not a variable but a constant.

Next an "insert" function for adding the records

in the table will be mentioned. By way of example, in the table R shown in Fig. 7, three records 7, 15 and 16 can be added with the aid of the "insert" function as follows:

```
(insert 'R
        '(RS# RSNAME LR RL)
        '((7 RUN RUNS RUNS-ON)
          (15 DEVELOPMENT
              HAS-DEVELOPED IS-DEVELOPED-BY)
          (16 SUBJECT
              IS-SUBJECT-OF SUBJECT-IS)))          (11)
```

For updating the record, a function "update" can be employed. Byway of example, in the table R (Fig. 7), the value of the record located on the column RSNAME where the value of the column RS# is can be updated to " 'THEME" by employing the function "update" as follows:

```
(update 'R
        'RSNAME
        "THEME
        '(eq (v RS#) 16))                      (12)
```

On the other hand, deletion of the record is performed as follows:

```
(delete 'R ' (eq (v RS#) 16))                  (13)
```

The second argument is a conditional term as is the case with the expression (12). Both the functions "update" and "delete" have arbitrary predicate functions other conditional term.

For selection of the record (i.e. retrieval of the record), a function "select" is employed.

```
(select '(LR RL)
        'R
        '(smatch '*SUBJ (v RSNAME)))      (14)
```

According to the above expression (14), the record located at the column RSNAME of the table R which partially coincides with a fragmental or partial character string "*SUBJ" is selected. Thereafter, the values of the same record which are located at the columns LR and RL are returned to the list. In the above expression, "smatch" is a predicate function employed for deciding whether the record matching with the fragmental or partial character string exists or not.

The main functions of the table manipulation module 2006 have been described. Next, the network traverse control module will be described together with methods of implementing main functions.

As described hereinbefore in conjunction with Fig. 2, the conceptual network is composed of the concept nodes and links termed "relation". The system remembers as a current node the concept constituting the key of the subject which the user is interested in. The user in turn is capable of browsing (traversing) in the network by employing the functions mentioned below. In this connection, it should be mentioned that "browsing or traversing" is equivalent to the displacement or movement of the current node.

Now, main network traverse or browse functions will be considered. As a procedure for moving the current

node, the name of the concept or a partial character string thereof may be first entered. When it is found at this step that a plurality of concepts which coincides with the partial character string are present, a menu table is displayed so that the user can select one of the displayed concepts, the result of which is transferred to the current node. Fig. 11 shows a display of the menu of concepts which coincides with the partical character string "*DATABASE", wherein the seventh concept in the menu has been selected. The mark "*" indicates that a string of characters following the mark is the partial (incomplete) character string. The above function can be realized by selecting the concept in accordance with

```
(select '(C# CNAME)
        'C
        '(smatch str (v CNAME)))          (15)
```

and calling separately the menu selecting function (select-one a-list). In the above expression, "str" is variable for character string entered at the terminal.

A second browse or traverse procedure is to sequentially trace or follow the conceptual tree (hierarchical tree) by resorting to the menu selection. Fig. 12 shows a menu of concepts ranking immediately below the uppermost concept UNIVERSAL with command "ℓ". Starting from the menu shown in Fig. 12, the hierarchical tree can be followed downwardly by inputting the desired concept numbers in the menus in a manner illustrated in Fig. 13. More specifically, in the case of the example

shown in Fig. 13, the concept "organization" has been reached by inputting the numbers "6", "1", "1" and "2" in this order. At this point, if the partial or incomplete character string is inputted, the concept matching with the partial character string is carried out only for the set of concepts subsumed by the current node (i.e. in this exemplary case "organization"). By way of example, among the eleven concepts shown in Fig. 11, only the eleventh concept (name of company) "RELATIONAL-DATABASE-SYSTEM-INC" would be selected. In other words, only this concept is subsumed by the concept "organization".

The concept subsumed by a given concept C can be derived in a manner mentioned below. First, in accordance with

(select '(C#) 'S '(eq (v S#) C)) (16)

the concept directly subsumed by the given concept (i.e. the concept directly underlying the given concept in the hierarchical tree) is selected. Accordingly, by calling recursively the same function, all the concepts subsumed by the given concept C can be selected.

A third browse procedure can be carried out by displaying graphically the conceptual or hierarchical tree on the CRT. Fig. 14 shows a concept tree be inning with a concept "space" down to the second hierarchy. By designating a given node of the concept tree displayed on the CRT 210 by means of the mouse 230 shown in Fig. 10, the current node can be moved to the designated node or the portion of the concept tree immediately underlying the

designated concept can be displayed. It should be pointed out that information of the position or location on the CRT 210 designated by the mouse 230 is received by the dialogue control module 2001. Since this module is destined to control the graphic display, the module can memorize what is displayed at which locations on the CRT. Accordingly, in response to the input information of a location, the control module 2001 can identify the concept being displayed at that location on the CRT at the most recent time point. Consequently, the dialogue control module 2001 inputs information of the cursor position and returns the concept name to the network traverse module 2005.

The graphical browse or traverse function can be realized not only by making use of the subsumption relations of the concepts illustrated in Fig. 14 but also by resorting to the part-whole relation. Fig. 15 shows a part of hierarchies of the concept "earth" in another conceptual tree configuration. The tree can be browsed, being directed by the part-whole relation in the utterly same manner as the case described above in conjunction with Fig. 14. The "part" concept can be extracted in the manner mentioned below. First, in accordance with

```
(select '(RS#)
        'R
        '(eq (v LR) 'HAS-PART-OF))          (17)
```

a set of the generic relationship identification numbers RS# representing the part-whole relations are called from the table R shown in Fig. 7. In the case of the example

illustrated in Fig. 7, "2223" is called and memorized temporarily at a variable x.

Assuming now that the concept which has as a part thereof a concept to be found out is represented by C, the concept constituting the part of C is derived in accordance with

```
(select '(CR)
        'r
        '(and (eq (v CL) C)
              (member (v RS#)x)))          (18)
```

where a small letter r is the name of the table shown in Fig. 8.

In the case where "HAS-PART-OF" is located at the column RL of the table R shown in Fig. 7, the concept constituting a part of the concept C can be obtained by implementing the expressions (17) and (18) with LR being exchanged by "RL" in the similar manner.

A fourth browse procedure resides in a chain-like traverse with the aid of frame representation. This procedure will be described in detail in conjunction with an example shown in Fig. 16. At first, a partial character string "*sowa" representative of a part of a man's name is inputted. Then, only "J.F. SOWA" is found out. The current node is moved automatically to this concept. The frame for this concept is displayed by a command fr for the frame display (the operand "*" means that the frame for the current node be displayed). From the frame displayed, it is found that "J.F. SOWA" is male "MAN" and that he is

author of "PAPER # 0012" and "BOOK # 0007". In this conjunction, when it is desired to know what is dealt with "PAPER # 0012", a command "fr 2" is inputted, resulting in that a frame for the second row of the frame being displayed is subsequently displayed. In the case of the example under consideration, the subsequent display tells that "PAPER # 0012" is "TECHNICAL PAPER" written by "J.F. SOWA" and contained in "IBM-RES & DEV-76-20" on pages 336 to 357. In the case of the example, the current node is moved from "J.F. SOWA" to "PAPER # 0012" and hence to "IBM-RES & DEV-76-20" and finally to "IBM-CORP".

The frame display is performed in the manner described above. Assuming now that the frame for the concept C is to be displayed in accordance with

```
(select '(RS#CR)
        'r
        '(eq (v CL) C))                    (19)
```

there can be obtained a set of pairs of a relation under concept where C is located on the lefthand side in the basic form and the concepts which are located on the right hand side. Similarly, from

```
(select '(RS#CL)
        'r
        '(eq (v CR) C))                    (20)
```

there can be obtained a set of pairs of a relation under concept in which C is located on the righthand side.

Assuming that said x is y are the results of procedures mentioned above, respectively,

```
(select '(LR)
        'R
        '(eq (v RS#) x1i))                    (21)
(select '(RL)
        'R
        '(eq (v RS#) y1i))                    (22)
```

return the names of instance relations, where x_i and y_i represent the i-th members of the set $\underline{x}$ and $\underline{y}$, respectively, and x_{1i} represents the first element of the member x_i and y_{1i} represents the first element of the member y_i. The names of these instance relations correspond to a first column of the frame (Fig. 16). More specifically, when the individual rows of the frame are termed as slots, the names under consideration correspond to the names of the slots, respectively. The second column of the frame contain the slot values representing the second elements x_{2i} and y_{2i} of the pairs x_i and y_i, respectively. Accordingly, by combining the slot names and the slot values in pairs and displaying then in a tabular form, a display such as shown in Fig. 16 can be produced. Since the concept is internally coded in terms of the concept identification number, transformation of the concept number to the concept name must be carried out by consulting the table C (Fig. 5) before generation of the display.

In the case of the example mentioned above, shift is made to a succeeding frame by designating the row number (slot number). However, it is also possible to

indicate directly the concept to which shift is to be made on the CRT by means of the mouse. Further, the frames can be displayed in sequential superposition.

Next, the concept network editor 2004 shown in Fig. 10 will be considered.

The concept network editor serves for maintenance of the knowledge base by performing definition and addition of novel concepts and/or relations, alternation and deletion thereof.

Fig. 17 illustrates an example of dialogue or interaction. First "man" is entered through the keyboard, resulting in that the current node is moved to the concept "MAN", which is followed by registration of a new man "SUPERMAN". Through a command "crc", "MR. SUPERMAN" can be registered at a run below "MAN". Namely,

(MR. SUPERMAN IS-A MAN) (23)

is registered.

Subsequently, the property of the newly registered concept "MR. SUPERMAN" is defined and registered in the form of the instance relation.

The system possesses knowledges in the generic form such that "a man devises a novel thing", "a man has an academic title" or "a man has a job of some sort". By taking advantage of these knowledge as prompt, the system can display the item to be inputted. By way of example, inputting of "MR. SUPERMAN" can be prompted in the form:

MR. SUPERMAN HAS-TITLE-OF {ACADEMIC TITLE}

The parenthesized concept "ACADEMIC TITLE"

indicates the class of property (a concept in the case of this example) to be inputted. The concept network traverse function is valid at this time point. The current node has been moved to the concept "ACADEMIC-TITLE" at that time point. Consequently, given traverse function can be employed in order to find out the property to be inputted. In the case of the example shown in Fig. 17, the concept name "phd" is directly inputted. However, it is also possible to display the concepts of the rank lower than the concept "ACADEMIC-TITLE" in the form of a menu (see Fig. 13) or display the conceptual tree (Fig. 14) for searching the desired concept. It should however be noted that the searching and browsing are restricted to the range of the lower rank concepts of "ACADEMIC TITLE". After the current node has been moved to the concept expressing the property to be inputted through the traverse function, "OK" is inputted for preparation for the inputting of succeeding property.

As will be appreciated from the above, only the properties to be inputted can be selected to be newly defined and registered in accordance with the prompts displayed by the system.

As described hereinbefore, one of the characteristic features of the invention resides in that the property is understood in terms of the instance relation to thereby allow both concepts to be equally dealt with. Accordingly, in the case of the example illustrated in Fig. 17, the facts

(PHD IS-GIVEN-TO MR. SUPERMAN)

(AAAI HAS-MEMBER-OF MR. SUPERMAN)

(JAPAN HAS-PEOPLE-OF MR. SUPERMAN)

(HITACHI-LTD HAS-EMPLOYEE-OF MR. SUPERMAN)

can be defined simultaneously.

New registration of concept can be internally realized in a manner mentioned below. Assuming now that the maximum C# (Fig. 5) is represented by C_{max}, the concept "MR. SUPERMAN" can be entered in the table C in accordance with

```
(insert 'C
        '(C# CNAME P/S)
         (list (add1 Cmax)
        'MR. SUPERMAN
        'P))                                    (24)
```

where the function "add 1" serves for incrementing by one (+1). In accordance with

```
(insert 'S
        '(C# S#)
         (list (add1 Cmax)
               (get-c# 'M A N)))                (25)
```

the fact expressed by the formula (24) can be entered in the table S. The function "get-C" serves for deriving from the concept name the identification number of that concept.

Registration of the instance relation can be performed relative to the name relation (property) in the manner mentioned below.

```
(insert 'r
        '(R# RS# CL CR G/I)
         (list (addl r#max)
               rs
               (get-c# 'MR. SUPERMAN)
               (get-c# 'PHD)
               'I))                                    (26)
```

where "rs" is the identification number of the generic relationship "ACADEMIC-TITLE", and "r # max" represents the maximum R # in the table r at that time point.

Another function of the concept network editor is alteration and/or modification (correction) of the facts and concepts which have already been registered. More specifically modification or correction of the name of concept, modification (correction) of positions in the conceptual tree (modification of classification), modification (correction) of the instance relation and generic relationship can be performed.

Fig. 18 shows an example of modification of the conceptual tree in which the position of a concept "PSYCHOLOGY" is to be changed from a class "SOCIAL-SCIENCE" to a class "NATURAL-SCIENCE". This change can be realized in accordance with

```
(update 'S
        'S#
        '(get-c# 'NATURAL-SCIENCE)
        '(eq (v C#)
             (get-c# 'PSYCHOLOGY)))                    (27)
```

As described hereinbefore, in the concept network editor, the network browsing function can be employed as desired. Similarly, the network editor function itself can be recursively employed. In reality there arises often such situation in which another concept is required to be newly entered in the course of registration of the definition of a new concept. In the case of the example illustrated in Fig. 17, when a concept "AAAI" to be inputted has not yet been entered in the class "ACADEMIC-ASSOCIATION", the instruction or command "crc" is newly inputted at this time point to thereby allow the concept "AIII" to be entered. Furthermore, the property of "AAAI" may be registered at that time point under the instruction "crr", if desired.

Moreover, there arises also such situation in which in the course of registration of a new concept, registration of false "fact" is found. In that case, the function of modification and/or alteration can be executed without delay. Due to such recursiveness, new knowledge can be additionally entered with improved efficiency.

Next, description will be made of the query formula generation module 2003 and the search and concept matching module 2002 shown in Fig. 10. These modules constitutes a major portion for making possible semantic content retrieval from fragmentary ambiguous information. Before entering into description of the function, a processing flow will be considered in conjunction with an exemplary retrieval. It is assumed that "article concerning

a computer developed by a company residing in Calfornia state which computer runs under UNIS" (28). CUNIX is a registered trade mark of Bell Laboratory.

Referring to Fig. 10, the current node is moved to the concept "ARTICLE" and an instruction g is inputted to start the generation of search (retrieval) formula. The system determines the generic relationships defined for the concept "ARTICLE" inclusive of those inherited from the superclass concept to display them in the frame format, as shown in Fig. 19. More specifically, the frame containing the generic knowledges "ARTICLE is -PART-OF PUBLISHED MATERIAL", "ARTICLE is -IN-PAGES-OF SO AND SO", "ARTICLE is -REFERRED-TO-FROM ARTICLE" and others is displayed. Then, the user can add more concrete information than the one being currently displayed, by designating a corresponding slot with the identification number assigned thereto. In the case of the example illustrated in Fig. 19, the fifth slot is selected because the information that the subject of the article is a computer is known to the user. In response thereto, the system moves the current node to the superclass concept (i.e. concept of higher rank) of the item to be entered. In this case, the current node is moved to the concept "UNIVERSAL". At this time, the user may use the any given network traverse function (refer to Fig. 10). In the case of the example illustrated in Fig. 19, "computer" is directly inputted to thereby move the current node to the concept "COMPUTER". However, unless the user can recall the name of the concept

to be inputted (in this case, computer), it can be determined by inputting the incomplete character string displaying the menu. In the case of the example under consideration, since further information of the computer exists, the instruction q is successively inputted in succession to the inputting of "computer".

Fig. 20 shows a display content for the dialogue or interaction. It will be seen that the generic relationships concerning the concept "COMPUTER" are displayed in a frame structure. Similarly to the preceding procedure, the slot for the condition to be added (the fourth slot in this case) is selected. Then, it is displayed that the class of item to be inputted is "ORGANIZATION.WORKPLACE". At this step, the selection from menu (refer to Fig. 13) can be employed. In the case of the present example however, "company" meaning "a certain company" is solely inputted straightforwardly. Since there exists information to be added for "company", the instruction q is succeedingly inputted to continue the process of generating the retrieval formula.

Fig. 21 illustrates a frame display of the generic relationships for the concept "COMPANY". By selecting the seventh slot, the condition that the company under search is located in California. It should be noted that "CALIFORNIA" is selected by inputting the incomplete character string "CAL". The concepts ranked lower than the concepts "SPACE", "PLACE" and "LOCATION" are shown in Fig. 14.

Completion of inputting the conditions is informed to the system by inputting "ok". Fig. 22 illustrates a case where conditions are again inputted in connection with the concept "COMPUTER" upon completion of inputting the conditions for "COMPANY". At this time, the thirteenth slot is selected to thereby input the information that "the same computer runs under the operating system UNIX".

When the procedures described above have been completed, the retrieval condition given by the expression (28) is replaced by the following formal expression:

```
(ARTICLE
  (SUBJECT-IS
(COMPUTER
  (RUNS-UNDER UNIX)
  (IS-DEVELOPED-AT
    (COMPANY
      (IS-LOCATED-IN CALIFORNIA))))))    (29)
```

As will be seen from the above, automatic generation of the retrieval formula is performed under the guidance of the generic knowledges described in terms of the generic relationships. Most of the generic knowledges are inherited from the concept of upper rank. By way of example, referring to Fig. 21, although "COMPANY is-A ORGANIZATION.WORKPLACE", most of the slots (generic relationships) in that frame are defined for the upper concept "ORGANIZATION.WORKPLACE", the slot inherent to the concept "COMPANY" is only the slot "PRODUCES MACHINERY. DEVICES". In this way, when the generic relationships

representing the generic knowledges are expressed literally more generically (i.e. with higher rank concepts), the generic relationships can have greater significance. In other words, they can be applied to a greater number of the concepts of lower rank.

The generic relationship of a concept C can be determined in the manner mentioned below. It is now assumed that a set of the concepts ranking higher than the concept C is represented by $\underline{x}$. (The set can be determined by following the link "IS-A" in the table S up to the concept "UNIVERSAL".) In accordance with

```
(select '(RS# CR)
        'r
        '(and (member (v CL) x)
              (eq (v G/I) 'G)))          (30)
```

the generic relationship in which the concept C is defined on the lefthand side is extracted from those inherited to the concept C. It will be understood that the generic relationship in which the concept C is defined on the righthand side can be obtained by replacing CL by CR in the expression (30). As will be seen from the above expression (30), what is obtained is a pair of RS# and CL or CR. From RS#, the slot name of the frame can be determined by consulting the table R. Assuming the answer of the expression (30) is in the form of

$$\{(y_{11}, y_{21}) \cdots (y_{1i}, y_{2i}) \cdots \},$$

```
(select '(LR)
        'R
        '(eq (v RS#) y1i))          (31)
```

Accordingly, the slot name corresponding to the i-th y can be obtained. When C1 is replaced by CR in the expression (30), then LR is replaced by RL in the expression (31) (refer to Fig. 7).

When the answer of the expression (31) is written as $\{(z_1) \ldots (z_i) \ldots\}$, the pair $(z_i y_{2i})$ consists of the slot name and the concept identification number. In accordance with

```
(select ' (CNAME)
        'C
        '(and (eq (v C#) y2i)
              (eq (v P/S) 'P)))      (32)
```

the concept name C_i is derived, resulting in that the pairs $(Z_i C_i)$ represents the slot name and the slot value. By displaying the list $\{(Z_1 C_1)(Z_2 C_2) \ldots (Z_i C_i) \ldots\}$ in the tabular form, the frame of the generic relationships can be obtained, as illustrated in Fig. 21.

When the search instruction is inputted for the automatically generated retrieval condition formula (e.g. expression 29), concept matching is performed relative to the set of terminal concepts of the current node (i.e. the concepts corresponding to the leaves of a concept subtree). More specifically, each of the terminal concepts (the most concrete concepts) in compared with "abstract concept" expressed by the retrieval condition formula, resulting

in the terminal concept subsumed by the abstract concept.

Fig. 23 shows the search in accordance with the retrieval condition 3000 given by the expression (29). It is possible to produce the frame display 3001 of the concepts of an article meeting the condition and the display of a document image 3051. It should be noted that the concept frame of the symbol "ARTICLE # 0014" does not coincide with the retrieval condition (29) at all in appearance. Such situation will occur in the information retrieval for the hitherto known data base. More specifically, since the most concrete information is stored in the hitherto known data base, there take place no coincidence at all when the retrieval condition is abstract. In contrast, according to the teachings of the present invention, the gap between the concrete contents of the concept frame and the abstract expression of the retrieval condition is eliminated by inference based on the world knowledges.

Next, description will be made of a matching method in which inference is resorted to for eliminating possible gap existing between the abstract concept and the concrete concept. This method or procedure is referred to as the concept matching. Fig. 29 illustrates a process of the concept matching between as abstract concept given by the expression (29) and the concept "ARTICLE # 0014".

In the searching process, the terminal concepts "ARTICLE # 0001", ... , "ARTICLE # 0040" are, respectively, compared with the condition (29). However, for simplifica-

tion of description, only the terminal concept "ARTICLE # 0014" which succeeds in the matching will be considered.

First, (ARTICLE) and (ARTICLE # 0014) are compared with each other. From the frame 3001,

(ARTICLE # 0014 IS-A NEWS.ARTICLE)

and further

(NEWS.ARTICLE IS-A ARTICLE)

Accordingly,

(ARTICLE # 0014 IS-A ARTICLE)

By narrowing the condition by one step, it is checked whether

(ARTICLE (SUBJECT-IS COMPUTER)) (33)

is valid or not. From the frame 3001, it is seen that

(ARTICLE # 0014
(SUBJECT-IS HP-9000))

Accordingly, check may be made as to whether or not

(HP-9000 IS-A COMPUTER)

By following up the link 3003,

(HP-9000 IS-A SUPERCOMPUTER)

Further, when the link 3032 is followed up,

(SUPERCOMPUTER IS-A COMPUTER)

The above are apparent from the frames 3002 and 3004, respectively. Thus, the formula (33) applies valid. Accordingly, check is next made as to the validness of

(ARTICLE
(SUBJECT-IS
(COMPUTER (RUNS-UNDER UNIX)
(IS-DEVELOPED-AT

COMPANY)))) (34)

It can be seen directly from the frame 3002 that (COMPUTER RUNS-UNDER UNIX) applies valid. Concerning (COMPUTER IS-DEVELOPED-AT COMPANY), the frame 3002 states

(HP-9000 IS-DEVELOPED-AT
HP.HEWLETT-PACKARD-CO)

Following the link 3033, it is stated in the frame 3004 that

(HP.HEWLETT-PACKARD-CO IS-A COMPANY)

Accordingly, statement in the frame 3002 is true, which means that the expression (34) applies valid.

Further narrowing the retrieval condition by one more step, comparison with the condition (29) is made. Since the frame 3004 states

(HP.HEWLETT-PACKARD-CO IS-LOCATED-IN PALO-ALTO) (35)

it is necessary to check whether or not

(COMPANY IS-LOCATED-IN CALIFORNIA) (36)

Following the link 3034, the frame 3005 states:

(PALO-ALTO IS-PART-OF CALIFORNIA) (37)

Accordingly, in combination with the expression (35), it is inferred that

(HP.HEWLETT-PACKARD-CO IS-LOCATED-IN CALIFORNIA)

Thus, it is found that the abstract concept (29) subsumes the concrete concept "ARTICLE # 0014".

In the foregoing, the concept matching has been elucidated in connection with a concrete example. Briefing the above procedure, it can be stated that the process for checking the presence of the subsumption relation between concepts and the process for checking the coincidence

between the individual slots are alternately and recursively called for proceeding with the procedure. Further, the procedure adopts the backward-changing inference. Accordingly, the time taken for the searching is basically proportional to the number of the concrete items subjected to retrieval.

In the concept matching, the concrete concept is returned as a value when the matching is successful. By inserting this value in the abstract concept, it becomes apparent ultimately why a certain concrete concept has matched. According to the invention, an instruction "why" is inputted, as the result of which the reason why the matching was found is displayed and outputted. In the case of the example given by the expression (29), there is outputted

```
(ARTICLE # 0014
(SUBJECT-IS
  (HP-9000
    (RUNS-UNDER UNIX)
    (IS-DEVELOPED-AT
      (HP.HEWLETT-PACKARD-CO
        (IS-LOCATED-IN PALO-ALTO))))))          (38)
```

Thus, it is found that the computer stated abstractly in the course of retrieval is "HP-9000" and that a certain company is "HP.HEWLETT-PACKARD-CO".

The present invention also provides means for translating the knowledge expressed by the concept network into tabular form familiar for the user and allowing the

retrieval on the table. An example of such means is illustrated in Fig. 25. After the current node has been moved to an abstract concept "NEWS.ARTICLE", an instruction "tab" is inputted. Then, the system generates internally a concept frame of the terminal concept of the abstract concept. Subsequently, the slot names appearing in the concept frame are presented in the form of a table. In the case of the example illustrated in Fig. 25, it is assumed that six varieties of slots are present. The user can select the slots which is to be transformed to columns of the table. In the case of the illustrated example, the sixth and fifth slots, i.e. "TITLE-IS" and "SUBJECT-IS" are selected, whereby a table including three columns in total is prepared. The user may search out the desired item on the basis of sentences contained in the column "TITLE-IS". The selected result is set as the current node and an instruction for displaying the document image is inputted. Then, the document image is displayed on the CRT 500.

The retrieval system according to the present invention can be applied not only to the document filing but also to more general purpose such as retrieval of data in general and information of facts or actual things. Further, the concept matching which is capable of automatically determining the subsumption relation between two concept is also applicable as information analyzing technique for examining whether the subsumption relation exists between claims of patents. Moreover, cluster

analysis of concepts is possible by collecting an enourmous amount of concrete concepts and applying the inventive concept matching. In the foregoing description of the preferred embodiments of the invention, it has been assumed that the system is destined for handling knowledges and documents written in English. However, the invention may be readily so embodied that knowledges and documents stated in other languages can be equally processed without departing from the spirit and scope of the invention. Those portions which depend on the language are limited to the column "CNAME" of the table C shown in Fig. 5 and the columns "RSNAME", "LR" and "RL" of the table R shown in Fig. 7. Additionally, the system can be so extended that multiple languages can be concurrently handled. To this end, a column "LANG" is additionally prepared for the table D and J may be recorded in this column when the concerned language is Japanese and E may be recorded when the language is English.

Although the concept registering function is based on the system initiative interaction in which all the slot names are sequentially presented to the user, as illustrated in Fig. 17, it is possible to embody the invention in the user initiative system in which the generic frame such as shown in Fig. 19 is displayed to allow the user to input desired properties at his or her will. The type of interaction is identical with the one adopted in the retrieval formula generation and thus encompassed by the invention.

As a development of the invention, the concept of time can be introduced into the knowledge base. Usually, there takes place frequently such situations in which the time at or for which a fact is "true" is required to be designated. By way of example, a fact "MR. SUPERMAN IS-MEMBER-OF AAAI" is true from the time when SUPERMAN joined AAAI to the time when he secedes therefrom. Such time concept can be realized by correspondingly extending the table r containing the instance relations.

Another extension of the system can be realized in respect to the function for recording the sources of the individual facts. By way of example, the sources of information such as "who said so", "where it is written" and so forth can be recorded in the table r by correspondingly extending it. Further, an extent of reliability may be added.

The present invention is independent of the configuration in which the system is realized. In order to accomplish a high-speed processing, specific hardware may be introduced. Further, when the knowledge base becomes excessively large, variation in implementation such as division of the tables for storing the concepts and relations each into clusters can be made within the coverage of the present invention. When the concepts and others are to be expressed in Japanese, kana (Japanese alphabet) - Chinese character translating function is required. The system incorporating this function is also covered by the present invention.

As will now be appreciated from the foregoing description, it is possible according to the present invention to derive easily any desired information such as that of document starting from fragmentary information without necessity to know the actual architecture of the file or data base. Further, storage of information in such manner that information may be easily read out can be realized without any appreciable difficulty.

In more concrete, the world knowledge about the subjects to be filed are expressed in terms of the concept network for realizing the knowledge base, whereby addition of fresh knowledge, edition and dialogical inputting of retrieval conditions can be performed in a much facilitated manner. Although the knowledge is expressed in the forms of generic relationship and instance relation, the system is imparted with the capability of inferring and displaying, upon inputting of information, what is next to be inputted by the user and to what class the concept should belong on the basis of the generic relationship. This capability or function is architected on the basic principle. Application to new worlds and/or more delicate worlds is possible merely by addition or alteration of the knowledge base expressed by the concept network.

The system includes the concept network editor for allowing addition and/or alteration of the knowledge base. The editor is imparted with the function to display the status of the knowledge base having four or more network browsing functions in the form of the concept

tree, menu table, frame, or relation data base table. In conjunction with such display, it is also possible to browse from on to another different concepts in a sequential manner. The possibility of such abundant data viewing is due to adoption of the newly devised concept relation model. In particular, the function of browsing to different concepts while displaying the conceptual frame is well compatible to man's thinking faculty or process. Accordingly, with this function alone, the highly intelligent concept searching can be accomplished.

Further, owing to the inference based on the world knowledge, meaningful content retrieval can be accomplished starting from the fragmentary vague information. Even from the abstract information which is useless for the hitherto known system, semantically meaningful contents can be derived, ensuring the retrieval with high accuracy. Besides, since the retrieval condition can be designated for any given items to any extent of detail, the retrieval formula can be prepared so as to be compatible with the level of user's memory or recalling faculty.

CLAIMS

1. An information storage system which employs concept relation models expressing knowledges by concepts and relations defined between the concepts, comprising: first means for storing words expressing the concepts, respectively; second means for storing inter-concept subsumption relations for all the concepts; and third means for storing inter-concept relations except for said subsumption relations; and incorporating a first function for retrieving a certain concept from the words stored in said first means; a second function for selecting the more concrete concept by extracting with the aid of said second means a concept ranking lower than said concept retrieved through said first function; and a third function for searching a desired concept by extracting with the aid of said third means a concept related to the concept retrieved already.

2. An information storage system according to Claim 1, further including, fourth means for storing relations defined between the concepts, and fifth means for discriminating generic relationships and instance relations from each other in said concepts.

3. An information storage system according to Claim 2, wherein knowledge is expressed and managed in terms of a table managing names of the concepts, a table managing subsumption relations of the concepts, a table managing definitions of the generic relationships, and a table managing relations established between the concepts.

4. An information storage system according to Claim 2, wherein generation of abstract concept is based on a concept frame created by the generic relationships.

5. An information storage system according to Claim 1, further including means for generating abstract conceptual expressions in terms of combination of relations between the concepts.

6. An information storage system according to Claim 5, wherein generation of said abstract concept is based on a concept frame created by generic relationships.

7. An information storage system according to Claim 4, wherein information retrieval is realized by performing concept matching between all of the concrete concepts subjected to the retrieval and the abstract conceptual expression.

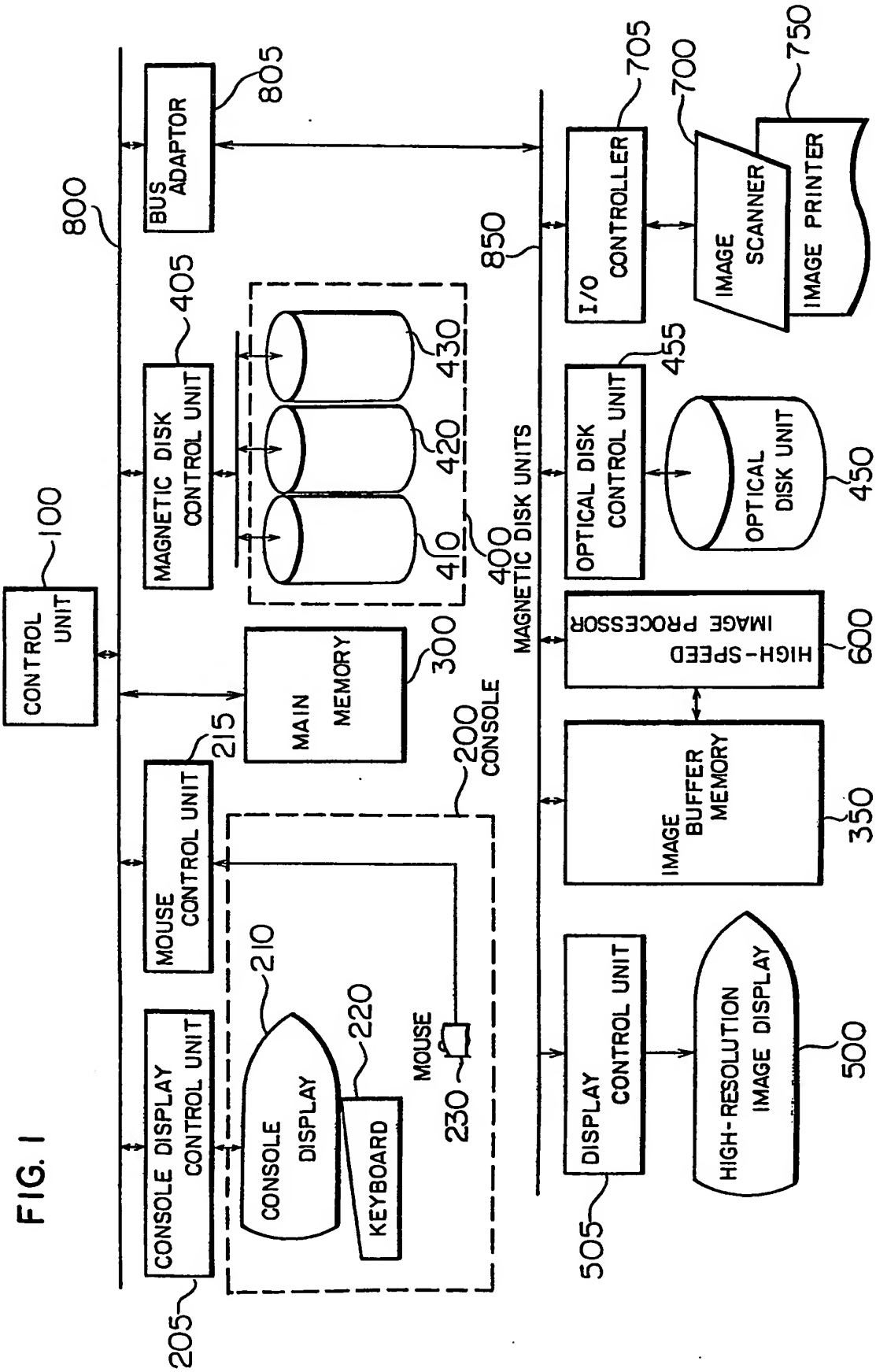

CONTROL UNIT
100
800
BUS ADAPTOR
805
MAGNETIC DISK CONTROL UNIT
405
410
420
430
400
MAGNETIC DISK UNITS
850
I/O CONTROLLER
705
IMAGE SCANNER
700
IMAGE PRINTER
750
OPTICAL DISK CONTROL UNIT
455
OPTICAL DISK UNIT
450
MAIN MEMORY
300
HIGH-SPEED IMAGE PROCESSOR
600
IMAGE BUFFER MEMORY
350
CONSOLE
200
MOUSE CONTROL UNIT
215
CONSOLE DISPLAY CONTROL UNIT
205
CONSOLE DISPLAY
210
KEYBOARD
220
MOUSE
230
DISPLAY CONTROL UNIT
505
HIGH-RESOLUTION IMAGE DISPLAY
500

FIG. 1

FIG. 2

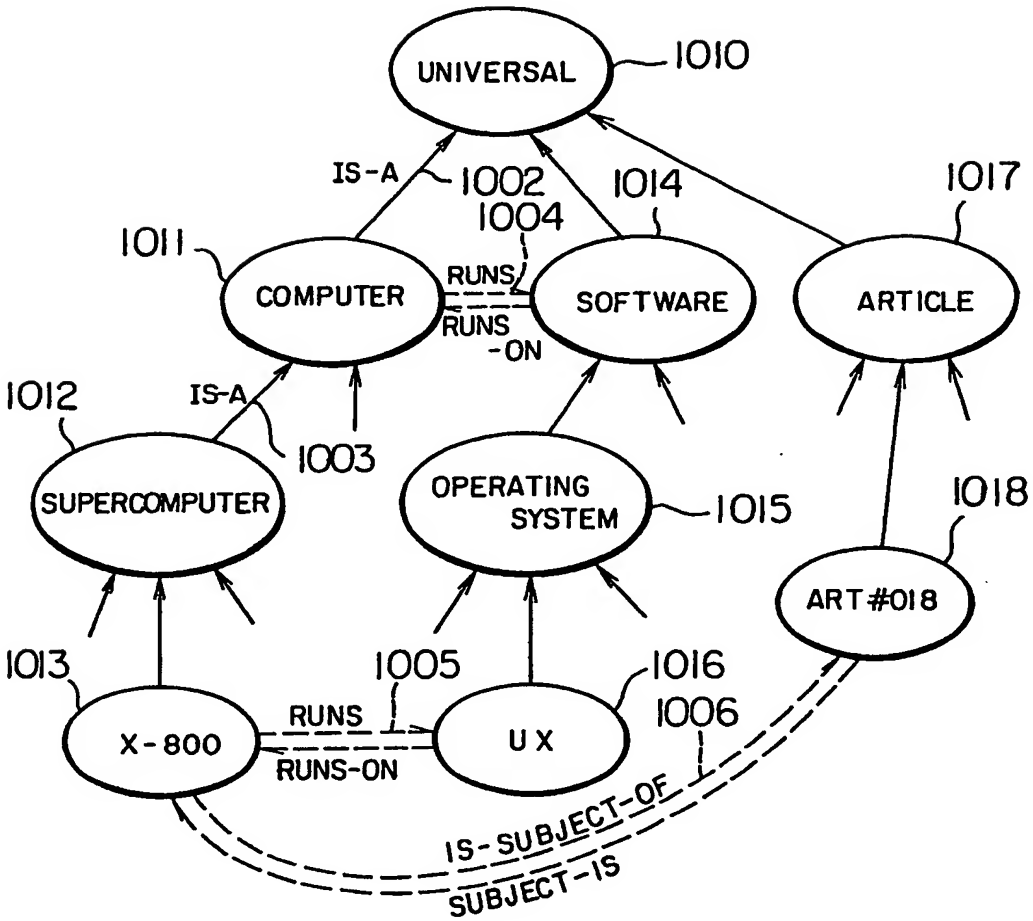

UNIVERSAL
1010
IS-A
1002
1004
1014
1017
1011
COMPUTER
RUNS
RUNS -ON
SOFTWARE
ARTICLE
1012
IS-A
1003
SUPERCOMPUTER
OPERATING SYSTEM
1015
1018
ART#018
1013
1005
1016
1006
X-800
RUNS
RUNS-ON
UX
IS-SUBJECT-OF
SUBJECT-IS

FIG. 3

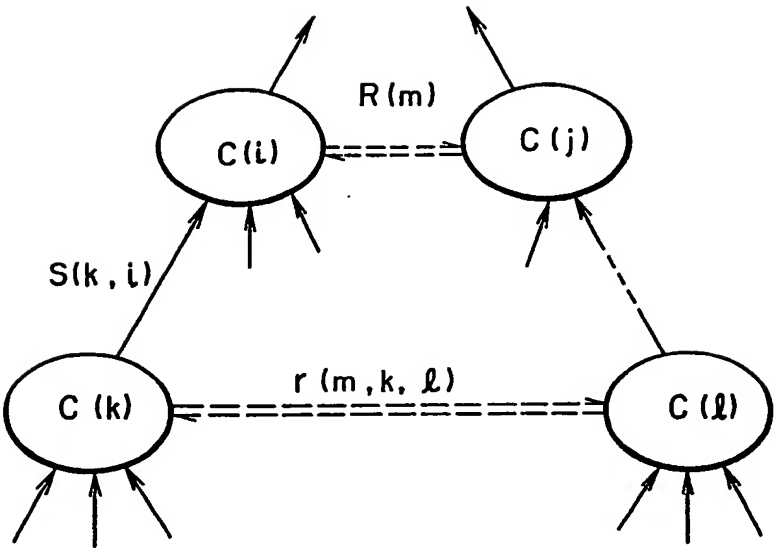


FIG. 4

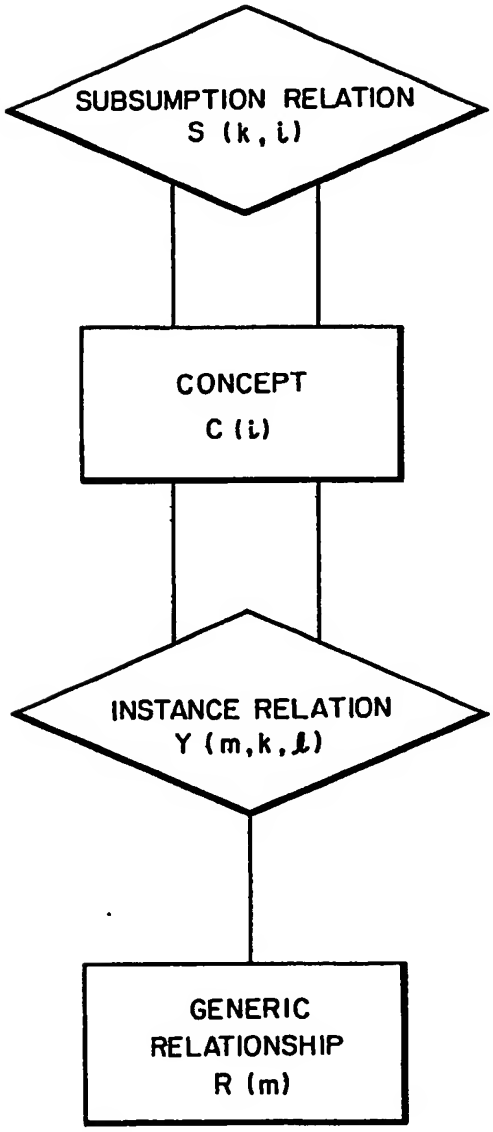

SUBSUMPTION RELATION
S (k, i)
CONCEPT
C (i)
INSTANCE RELATION
Y (m, k, ℓ)
GENERIC
RELATIONSHIP
R (m)

FIG. 5

C

C #	CNAME	P/S
1	UNIVERSAL	p
⋮	⋮	⋮
58	COMPUTER	P
58	(計算機)	S
⋮	⋮	⋮
64	SOFTWARE	P
⋮	⋮	⋮
107	SUPERCOMPUTER	P
⋮	⋮	⋮
251	ARTICLE	P
⋮	⋮	⋮
313	ART #018	P
⋮	⋮	⋮
1051	UX	P
⋮	⋮	⋮
1419	OPERATING-SYSTEM	P
⋮	⋮	⋮
1512	X-800	
⋮	⋮	

FIG. 6

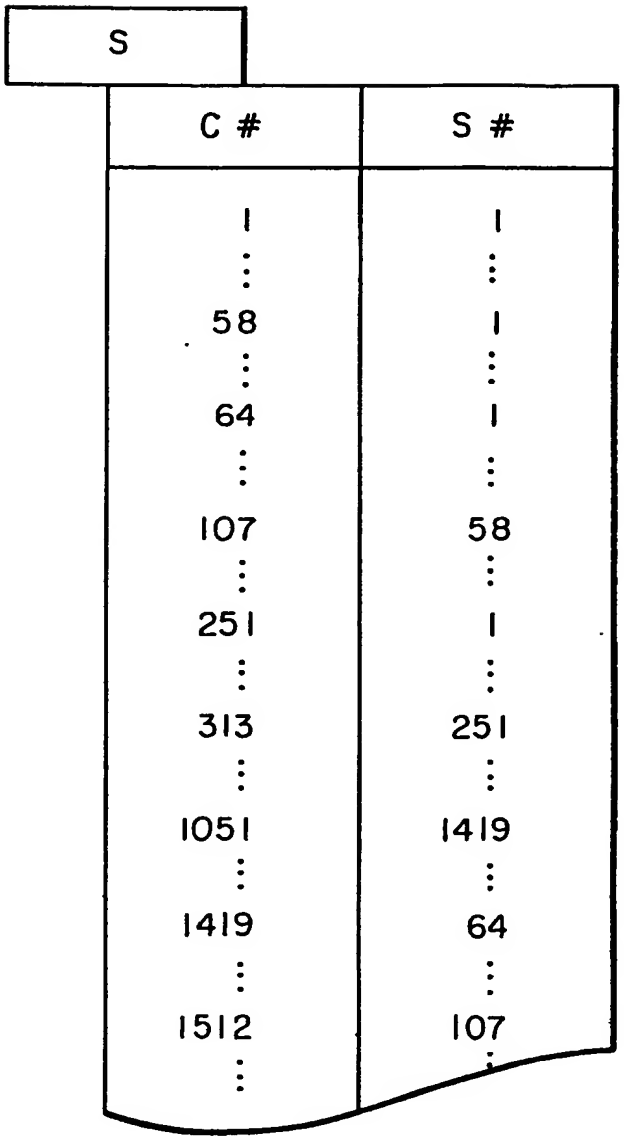


FIG. 7

R

RS#	RSNAME	LR	RL
⋮		⋮	
7	RUN	RUNS	RUNS-ON
⋮		⋮	
15	DEVELOPMENT	HAS-DEVELOPED	IS-DEVELOPED-BY
16	SUBJECT	IS-SUBJECT-OF	SUBJECT-IS
⋮		⋮	
21	AUTHORSHIP	HAS-WRITTEN	IS-WRITTEN-BY
22	PART-WHOLE 1	HAS-PART-OF	IS-PART-OF
23	PART-WHOLE 2	HAS-PART-OF	IS-PART-OF
24	PART WHOLE 3	IS-PART-OF	HAS-PART-OF
⋮			
34	LOCATION	IS-LOCATED-IN	IS-LOCATION-OF
⋮			

FIG. 8

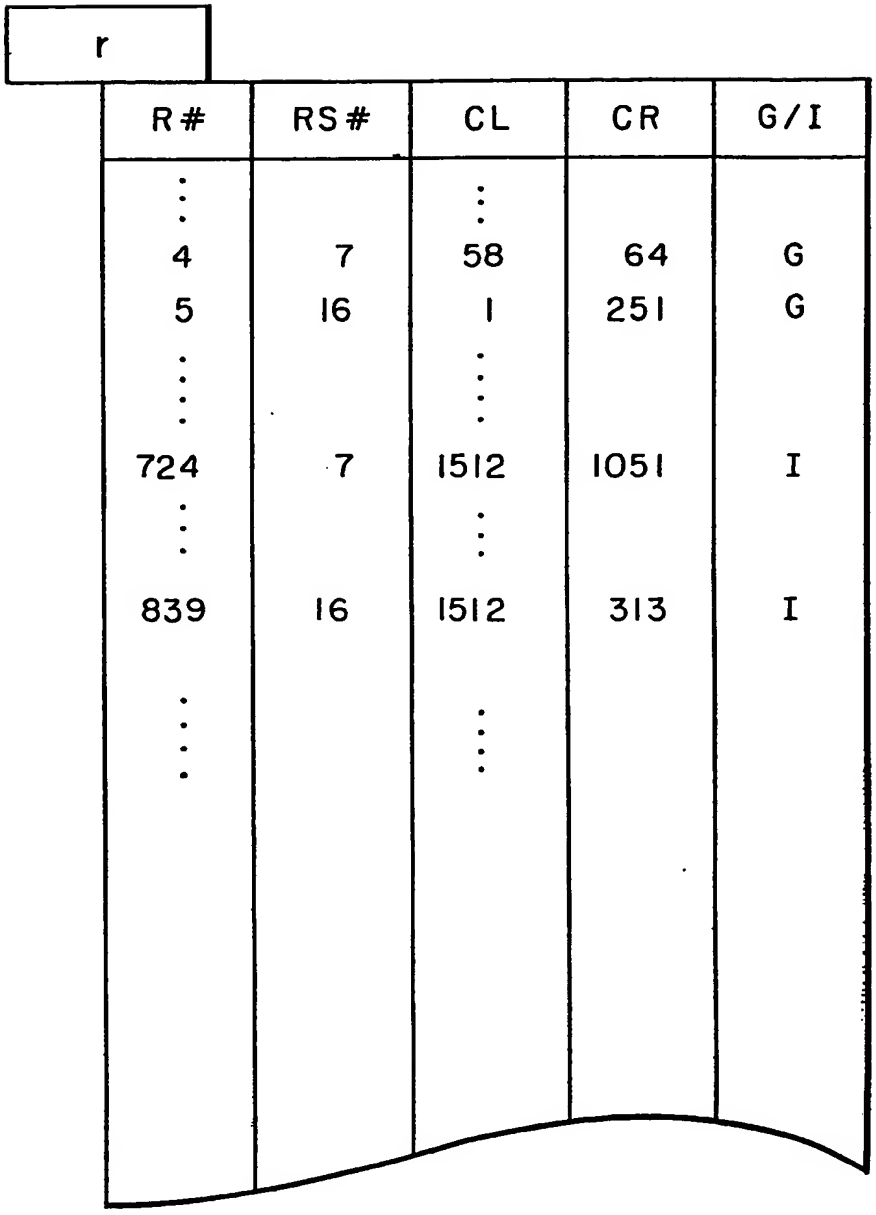
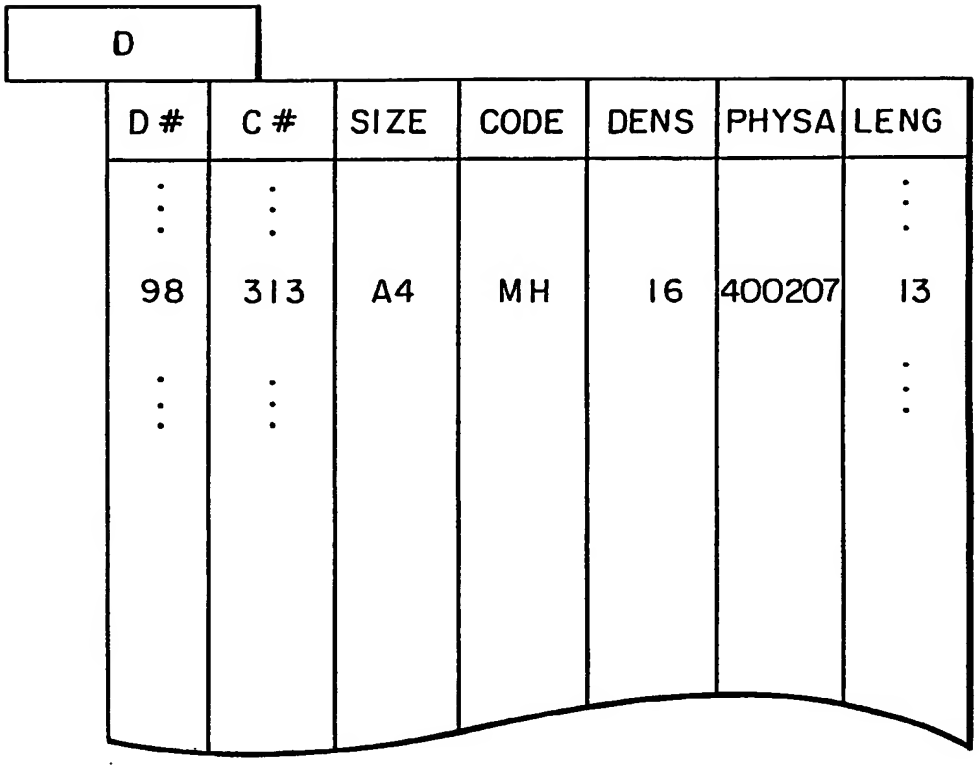

r
R#
RS#
CL
CR
G/I
4
7
58
64
G
5
16
1
251
G
724
7
1512
1051
I
839
16
1512
313
I

FIG. 9



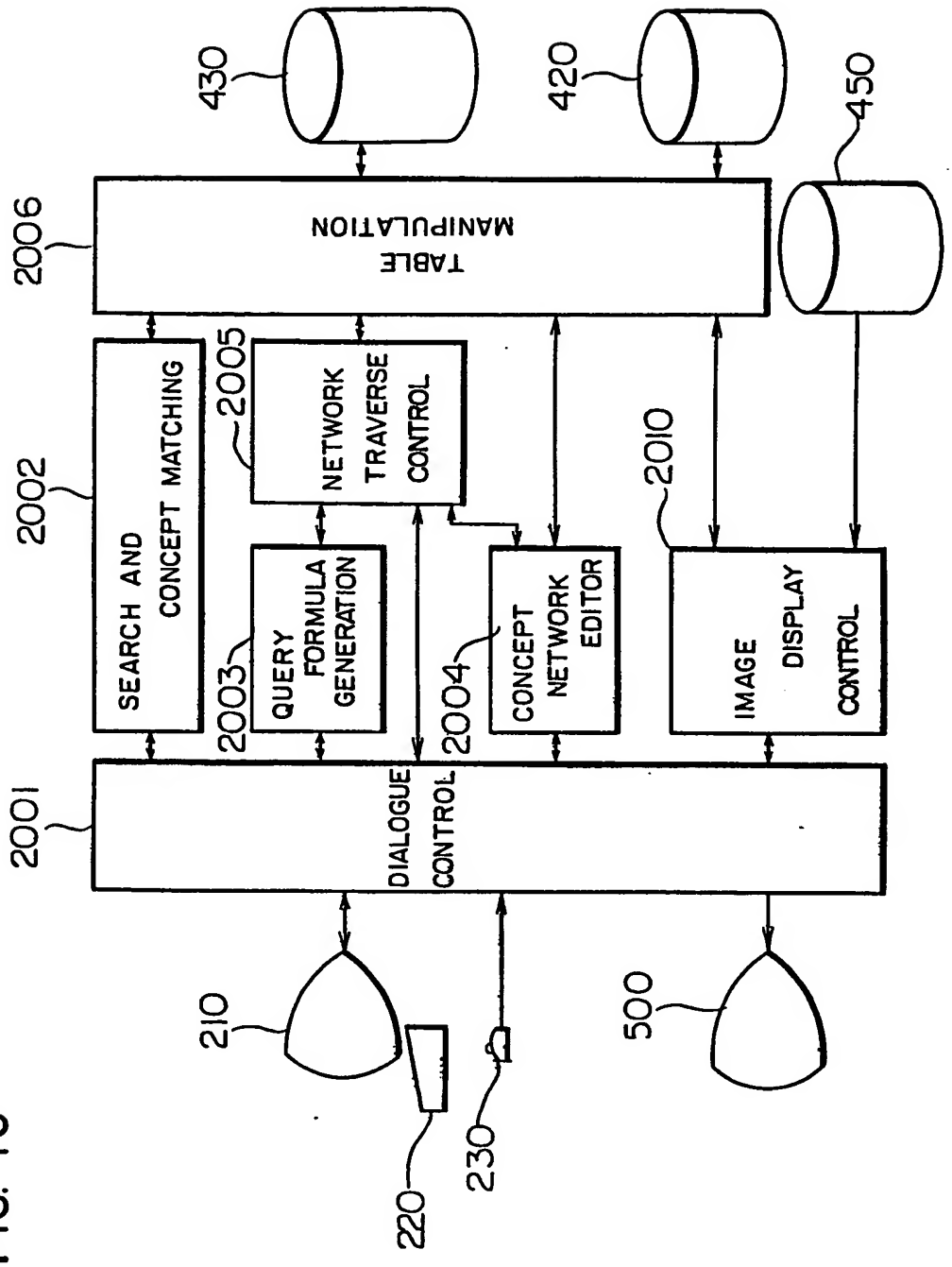

430
420
450
2006
TABLE MANIPULATION
2002
SEARCH AND CONCEPT MATCHING
2005
NETWORK TRAVERSE CONTROL
2010
2003
QUERY FORMULA GENERATION
2004
CONCEPT NETWORK EDITOR
IMAGE DISPLAY CONTROL
2001
DIALOGUE CONTROL
210
220
230
500

FIG. 10

11 /24

FIG. 11

NO	* DATABASE
1	acm Trans. on Database Systems
2	ACM-DATABASE-SYSTEMS-5-4
3	ACM-DATABASE-SYSTEMS-9-2
4	Conceptual graphs for a database interface
5	Coreference in a frame database
6	DATABASE-INTERFACE
7	DATABASE-MODEL
8	DBMS. DATABASE-MANAGEMENT-SYSTEM
9	RABBIT: An Intelligent Database Assistant
10	RELATIONAL-DATABASE-MANAGER
11	RELATIONAL-DATABASE-SYSTEMS-INC

? NUMBER: 7

FIG. 12

BROWSE > 1

NO	UNIVERSAL
1	ABSTRACT-RELATIONS
2	AFFECTIONS
3	CONCEPT
4	EVENT
5	INTELLECT
6	MATTER
7	SCIENCE. TECHNOLOGY
8	SENSATION
9	UNIVERSAL
10	VOLITION

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FIG. 13

BROWSE>6
BROWSE>ℓ

NO	MATTER
1	INORGANIC-MATTER
2	ORGANIC-MATTER

BROWSE>1
BROWSE>ℓ

NO	INORGANIC-MATTER
1	HUMAN-CREATION
2	NATURAL-MATERIAL

BROWSE>1
BROWSE>ℓ

NO	HUMAN-CREATION
1	MACHINERY. DEVICE
2	ORGANIZATION. WORKPLACE
3	PAPER-MATERIAL
4	SOFTWARE
5	SYSTEM. STRUCTURE

BROWSE>2
BROWSE>ℓ

NO	ORGANIZATION. WORKPLACE
1	ACADEMIC-ASSOCIATION
2	CENTER
3	COLLEGE. UNIVERSITY
4	COMPANY
5	GROUP
6	LIBRARY. BOOKROOM
7	OFFICE
8	RESEARCH-LAB
9	SCHOOL. DEPARTMENT
10	WORKS. FACTORY

FIG. 14

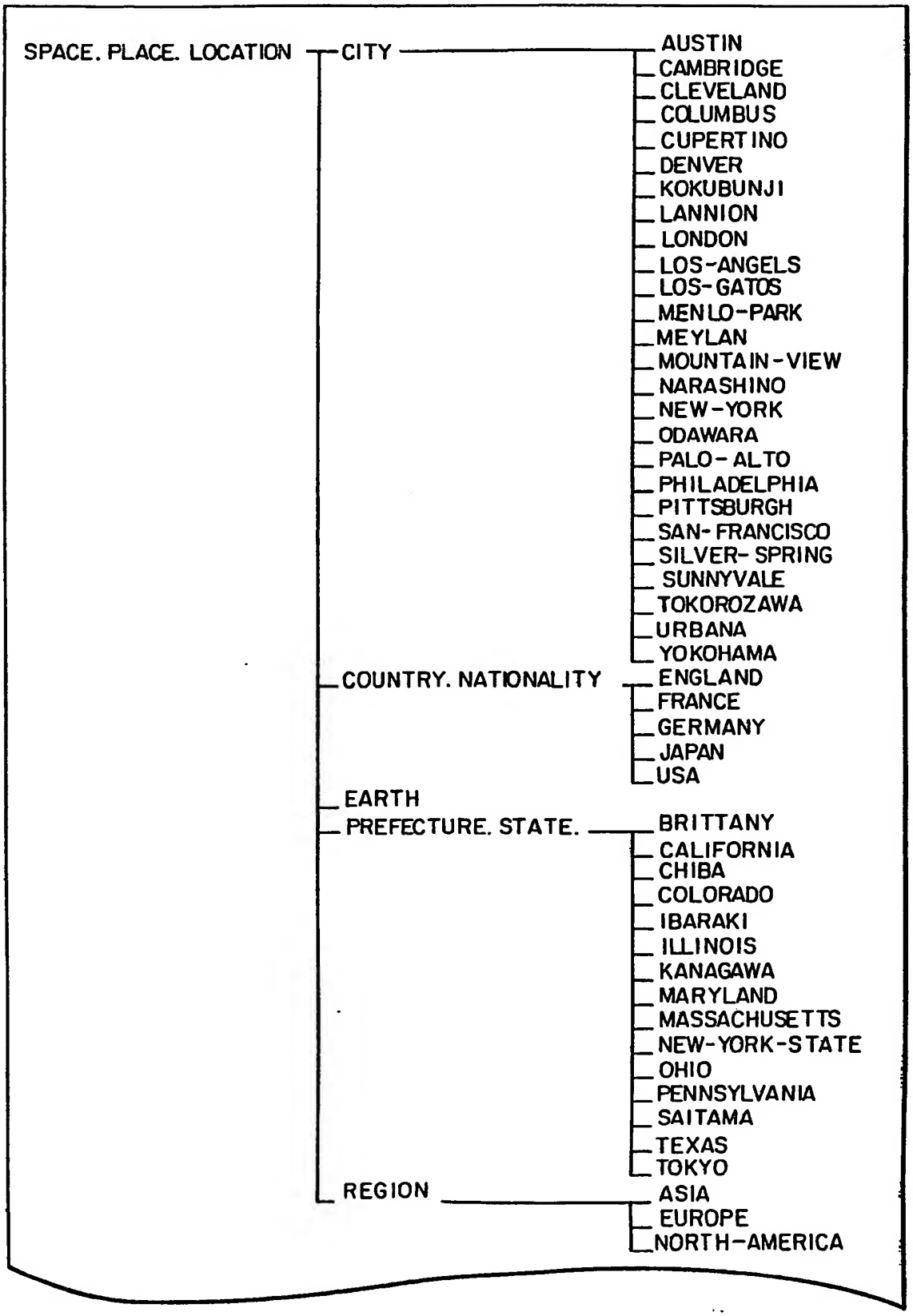

SPACE. PLACE. LOCATION
CITY
AUSTIN
CAMBRIDGE
CLEVELAND
COLUMBUS
CUPERTINO
DENVER
KOKUBUNJI
LANNION
LONDON
LOS-ANGELS
LOS-GATOS
MENLO-PARK
MEYLAN
MOUNTAIN-VIEW
NARASHINO
NEW-YORK
ODAWARA
PALO-ALTO
PHILADELPHIA
PITTSBURGH
SAN-FRANCISCO
SILVER-SPRING
SUNNYVALE
TOKOROZAWA
URBANA
YOKOHAMA
COUNTRY. NATIONALITY
ENGLAND
FRANCE
GERMANY
JAPAN
USA
EARTH
PREFECTURE. STATE.
BRITTANY
CALIFORNIA
CHIBA
COLORADO
IBARAKI
ILLINOIS
KANAGAWA
MARYLAND
MASSACHUSETTS
NEW-YORK-STATE
OHIO
PENNSYLVANIA
SAITAMA
TEXAS
TOKYO
REGION
ASIA
EUROPE
NORTH-AMERICA

FIG. 15

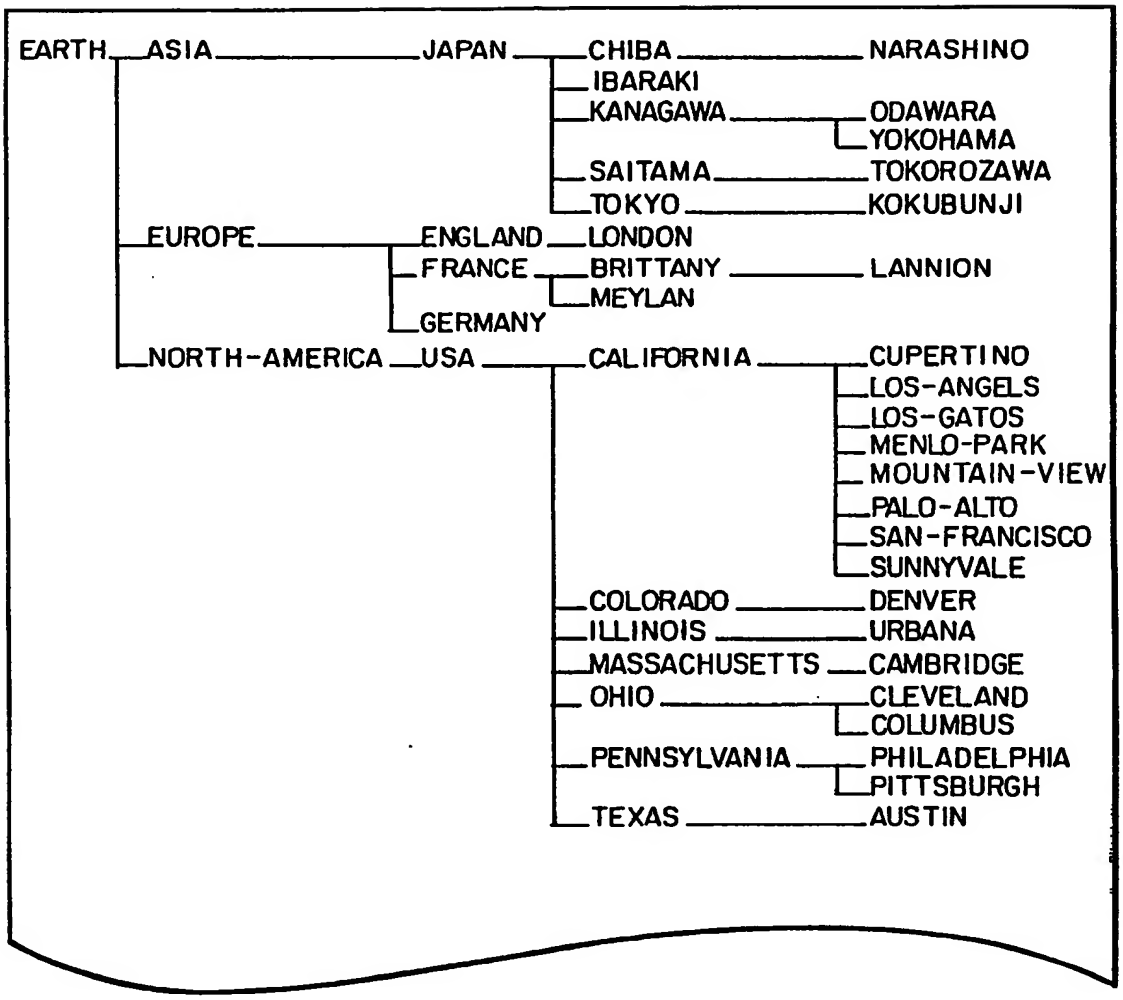

EARTH
ASIA
JAPAN
CHIBA
NARASHINO
IBARAKI
KANAGAWA
ODAWARA
YOKOHAMA
SAITAMA
TOKOROZAWA
TOKYO
KOKUBUNJI
EUROPE
ENGLAND
LONDON
FRANCE
BRITTANY
LANNION
MEYLAN
GERMANY
NORTH-AMERICA
USA
CALIFORNIA
CUPERTINO
LOS-ANGELS
LOS-GATOS
MENLO-PARK
MOUNTAIN-VIEW
PALO-ALTO
SAN-FRANCISCO
SUNNYVALE
COLORADO
DENVER
ILLINOIS
URBANA
MASSACHUSETTS
CAMBRIDGE
OHIO
CLEVELAND
COLUMBUS
PENNSYLVANIA
PHILADELPHIA
PITTSBURGH
TEXAS
AUSTIN

FIG. 16

BKOWSE> *sowa
BROWSE> fr *

J.F. SOWA.	CONCEPT	NO
IS-A	MAN	1
IS-AUTHOR-OF	PAPER #0012	2
IS-AUTHOR-OF	BOOK # 0007	3
NATIONALITY-IS	USA	4
WORKS-AT	IBM Systems Research Institute	5

BROWSE > fr 2

PAPER # 0012	CONCEPT	NO
IS-A	TECH-PAPER	1
AUTHOR-IS	J.F. SOWA	2
IS-IN-PAGES-OF	336-357	3
IS-PART-OF	IBM-RES & DEV-76-20	4
SUBJECT-IS	DATABASE-INTERFACE	5
TITLE-IS	Conceptual graphs for a database interface	6

BROWSE > fr 4

IBM-RES & DEV-76-20	CONCEPT	NO
IS-A	IBM J. Research and Development	1
HAS-PART-OF	PAPER # 0012	2
IS-PUBLISHED-BY	IBM-CORP	3

BROWSE > fr 3

IBM-CORP	CONCEPT	NO
IS-A	COMPANY	1
HAS-ANNOUNCED	ARTICLE # 0011	2
HAS-DEVELOPED	SERIES-1-MINICOMPUTER	3
HAS-PART-OF	IBM Systems Research Institute	4
HAS-PART-OF	WORKS. FACTORY	5
IS-LOCATED-IN	USA	6
PRODUCES	CPIX	7
PRODUCES	SERIES-1-MINICOMPUTER	8
PUBLISHES	IBM J. Research and Development	9

FIG. 17

```
BROWSE > man
MAN

BROWSE> crc mr. superman *
(MR. SUPERMAN (IS-A MAN))
% OK OR NO....OK
MR. SUPERMAN

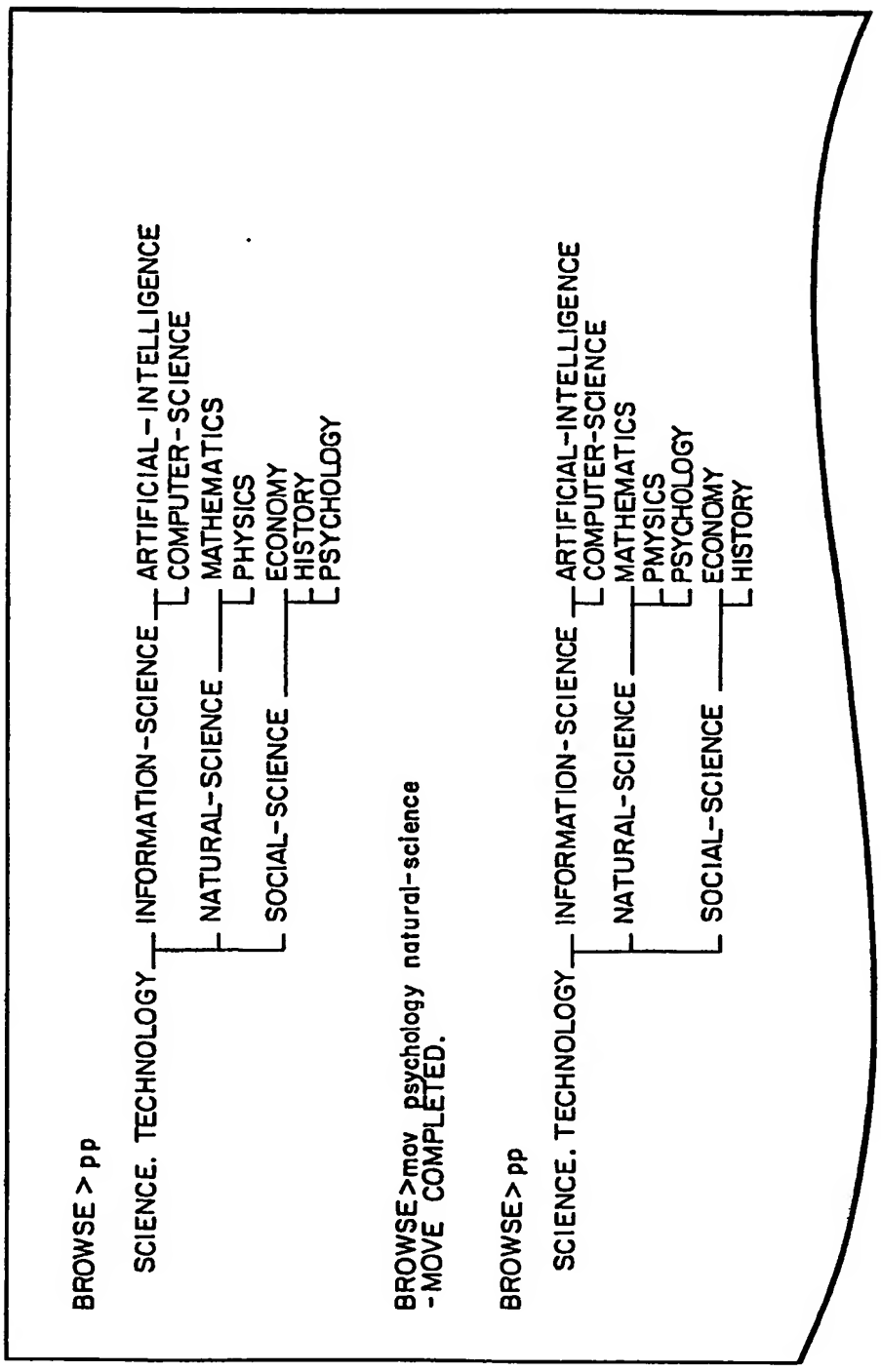
BROWSE> crr *
MR. SUPERMAN HAS PROPOSED [NORGANIC-MATTER] : computer
MR. SUPERMAN HAS PROPOSED [COMPUTER] : OK
MR. SUPERMAN HAS TITLE OF [ACADEMIC-TITLE] : phd
MR SUPERMAN HAS TITLE OF [PHD] : OK
MR. SUPERMAN IS A [JOB-POSITION] chief-researcher
MR. SUPERMAN IS A [CHIEF-RESEARCHER] : OK
MR. SUPERMAN IS A MEMBER OF [ACADEMIC-ASSOCIATICN] : aaai
MR. SUPERMAN IS A MEMBER OF [AAAI] : OK
MR. SUPERMAN IS AUTHOR OF [ARTICLE] : OK
MR. SUPERMAN IS AUTHOR OF [PUBLISHED-MATERIAL] : BOOK
MR. SUPERMAN IS AUTHOR OF [BOOK] : OK
MR. SUPERMAN IS EDITOR OF [PUBLISHED-MATERIAL] : OK
MR. SUPERMAN IS PERSON TO CONTACT FOR [CONFERENCE] : OK
MR SUPERMAN IS SUBJECT OF [PUBLISHED MATERIAL] : OK
MR. SUPERMAN IS SUBJECT OF [ARTICLE] : OK
MR SUPERMAN WHOSE NATIONALITY IS [COUNTRY. NATIONALITY] : japan
MR. SUPERMAN WHOSE NATIONALITY IS [JAPAN] : OK
MR. SUPERMAN WORKS AT [ORGANIZATION. WORKPLACE] : hitachi-ltd
MR. SUPERMAN WORKS AT [HITACHI-LTD] : OK

The followings are to be added to database.

((HAS-PROPOSED COMPUTER) (HAS TITLE OF PHD) (IS-A CHIEF-RESEARCHER)
 (IS-A-MEMBER-OF AAAI) (IS-AUTHOR OF BOOK)
 (NATIONALITY-OF-*-IS JAPAN) (WORKS-AT HITACHI-LTD))

Do you want to add them ? (y/n) y
```

FIG. 18


BROWSE > pp
SCIENCE. TECHNOLOGY
INFORMATION-SCIENCE
ARTIFICIAL-INTELLIGENCE
COMPUTER-SCIENCE
NATURAL-SCIENCE
MATHEMATICS
PHYSICS
SOCIAL-SCIENCE
ECONOMY
HISTORY
PSYCHOLOGY
BROWSE>mov psychology natural-science
-MOVE COMPLETED.
BROWSE> pp
SCIENCE. TECHNOLOGY
INFORMATION-SCIENCE
ARTIFICIAL-INTELLIGENCE
COMPUTER-SCIENCE
NATURAL-SCIENCE
MATHEMATICS
PMYSICS
PSYCHOLOGY
SOCIAL-SCIENCE
ECONOMY
HISTORY

18/24

FIG. 19

BROWSE> article
BROWSE > q
— I'm thinking which questions to be asked
— PIease add information you have.

ARTICLE	CONCEPT	NO
IS-IN-PAGES-OF	PAGE	1
IS-PART-OF	PUBLISHED-MATERIAL	2
IS-REFERRED-TO-FROM	ARTICLE	3
IS-REFERRED-TO-FROM	PUBLISHED-MATERIAL	4
SUBJECT-IS	UNIVERSAL	5
TITLE-IS	TITLE. HEADLINE	6

(ARTICLE)
?NUMBER : 5
ARTICLE WHOSE SUBJECT IS {UNIVERSAL} : computer
ARTICLE WHOSE SUBJECT IS {COMPUTER} : q

FIG. 20

— I'm thinking which questions to be asked.
— PIease add information you have.

COMPUTER	CONCEPT	NO
HAS-INTERFACE-OF	INTERFACE-DEVICE	1
HAS-PART-OF	MACHINERY. DEVICE	2
IS-ATTACHED-TO	COMPUTER	3
IS-DEVELOPED-AT	ORGANIZATION. WORKPLACE	4
IS-EQUIVALENT-TO	HUMAN-CREATION	5
IS-PRODUCED-BY	ORGANIZATION. WORKPLACE	6
IS-SUBJECT-OF	PUBLISHED-MATERIAL	7
IS-SUBJECT-OF	ARTICLE	8
IS-SUBJECT-OF	CONFERENCE	9
RESEMBLES	MATTER	10
RUNS	COMPUTER-SOFT	11
RUNS	PROGRAMMING-LANGUAGE	12
RUNS-UNDER	OS. OPERATING-SYSTEM	13

(COMPUTER)
?NUMBER : 4
COMPUTER IS DEVELOPED AT {ORGANIZATION. WORKPLACE} : company
COMPUTER IS DEVELOPED AT {COMPANY} : q

19/24

FIG. 21

— I'm thinking which questions to be asked.
— Please add information you have.

COMPANY	CONCEPT	NO
HAS-ANNOUNCED	NEWS. ARTICLE	1
HAS-DEVELOPED	MACHINERY. DEVICE	2
HAS-DEVELOPED	COMPUTER-SOFT	3
HAS-DEVELOPED	SYSTEM. STRUCTURE	4
HAS-EMPLOYEE-OF	PERSON	5
HAS-PART-OF	ORGANIZATION. WORKPLACE	6
IS-LOCATED-IN	SPACE. PLACE. LOCATION	7
IS-PART-OF	ORGANIZATION. WORKPLACE	8
PRODUCES	MACHINERY. DEVICE	9
PUBLISHES	PUBLISHED-MATERIAL	10

(COMPANY)
?NUMBER: 7
COMPANY IS LOCATED IN {SPACE. PLACE. LOCATION}:* cal
COMPANY IS LOCATED IN {CALIFORNIA}: OK

20/24

0 196 064

FIG. 22

COMPUTER	CONCEPT	NO
HAS-INTERFACE-OF	INTERFACE-DEVICE	1
HAS-PART-OF	MACHINERY. DEVICE	2
IS-ATTACHED-TO	COMPUTER	3
IS-DEVELOPED-AT	ORGANIZATION. WORKPLACE	4
IS-EQUIVALENT-TO	HUMAN-CREATION	5
IS-PRODUCED-BY	ORGANIZATION. WORKPLACE	6
IS-SUBJECT-OF	PUBLISHED-MATERIAL	7
IS-SUBJECT-OF	ARTICLE	8
IS-SUBJECT-OF	CONFERENCE	9
RESEMBLES	MATTER	10
RUNS	COMPUTER-SOFT	11
RUNS	PROGRAMMING-LANGUAGE	12
RUNS-UNDER	OS. OPERATING-SYSTEM	13

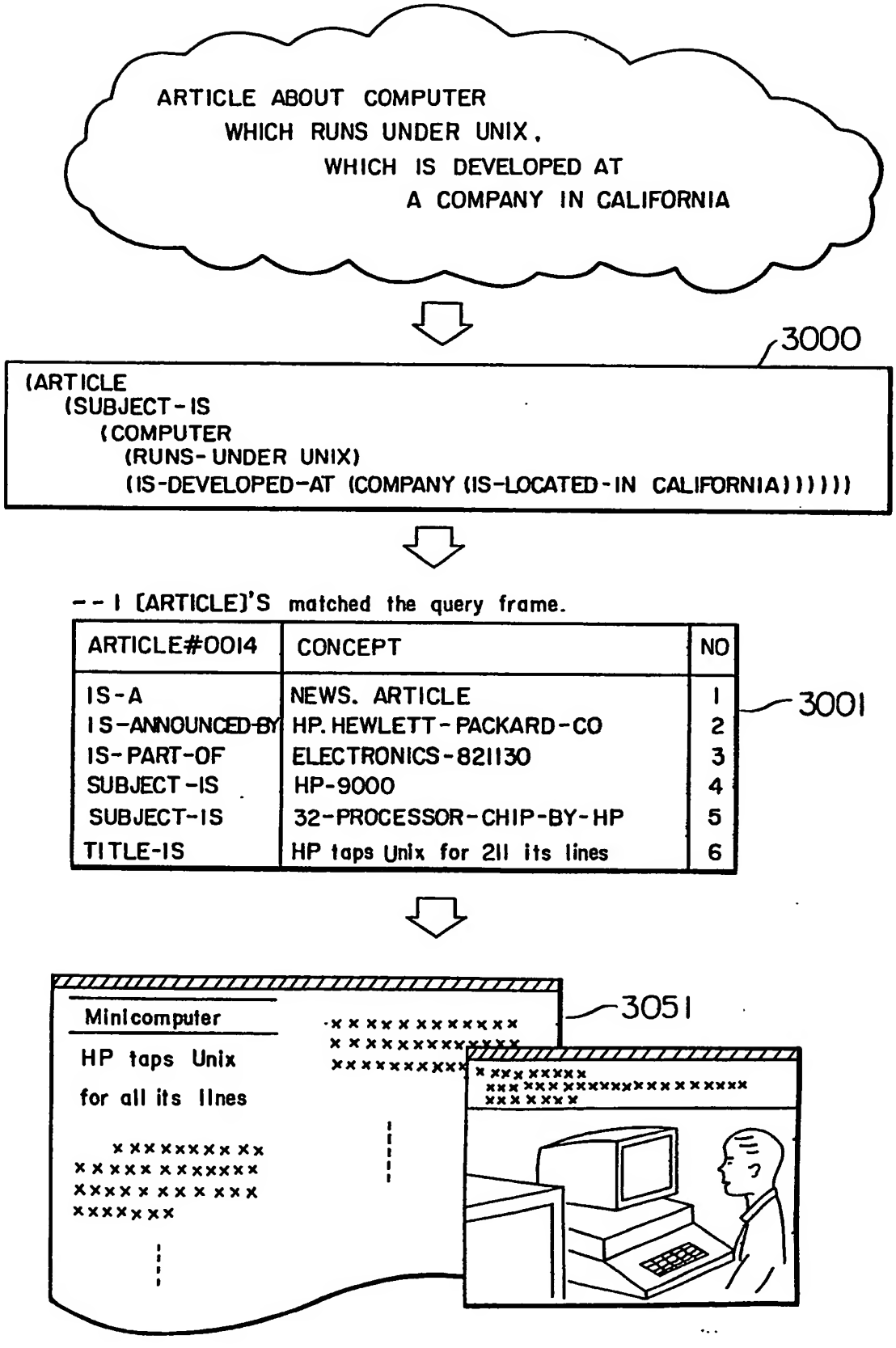
(COMPUTER (IS-DEVELOPED-AT (COMPANY (IS-LOCATED-IN CALIFORNIA))))
? NUMBER: 13
COMPUTER RUNS UNDER (OS OPERATING-SYSTEM): unix
COMPUTER RUNS UNDER {UNIX} : OK

21 / 24

0 196 064

22/24

FIG. 23


ARTICLE ABOUT COMPUTER
WHICH RUNS UNDER UNIX,
WHICH IS DEVELOPED AT
A COMPANY IN CALIFORNIA
3000
(ARTICLE
(SUBJECT-IS
(COMPUTER
(RUNS-UNDER UNIX)
(IS-DEVELOPED-AT (COMPANY (IS-LOCATED-IN CALIFORNIA)))))))
--1 [ARTICLE]'S matched the query frame.
ARTICLE#0014
CONCEPT
NO
IS-A
NEWS. ARTICLE
1
IS-ANNOUNCED-BY
HP. HEWLETT-PACKARD-CO
2
IS-PART-OF
ELECTRONICS-821130
3
SUBJECT-IS
HP-9000
4
SUBJECT-IS
32-PROCESSOR-CHIP-BY-HP
5
TITLE-IS
HP taps Unix for 211 its lines
6
3001
Minicomputer
HP taps Unix
for all its lines
3051

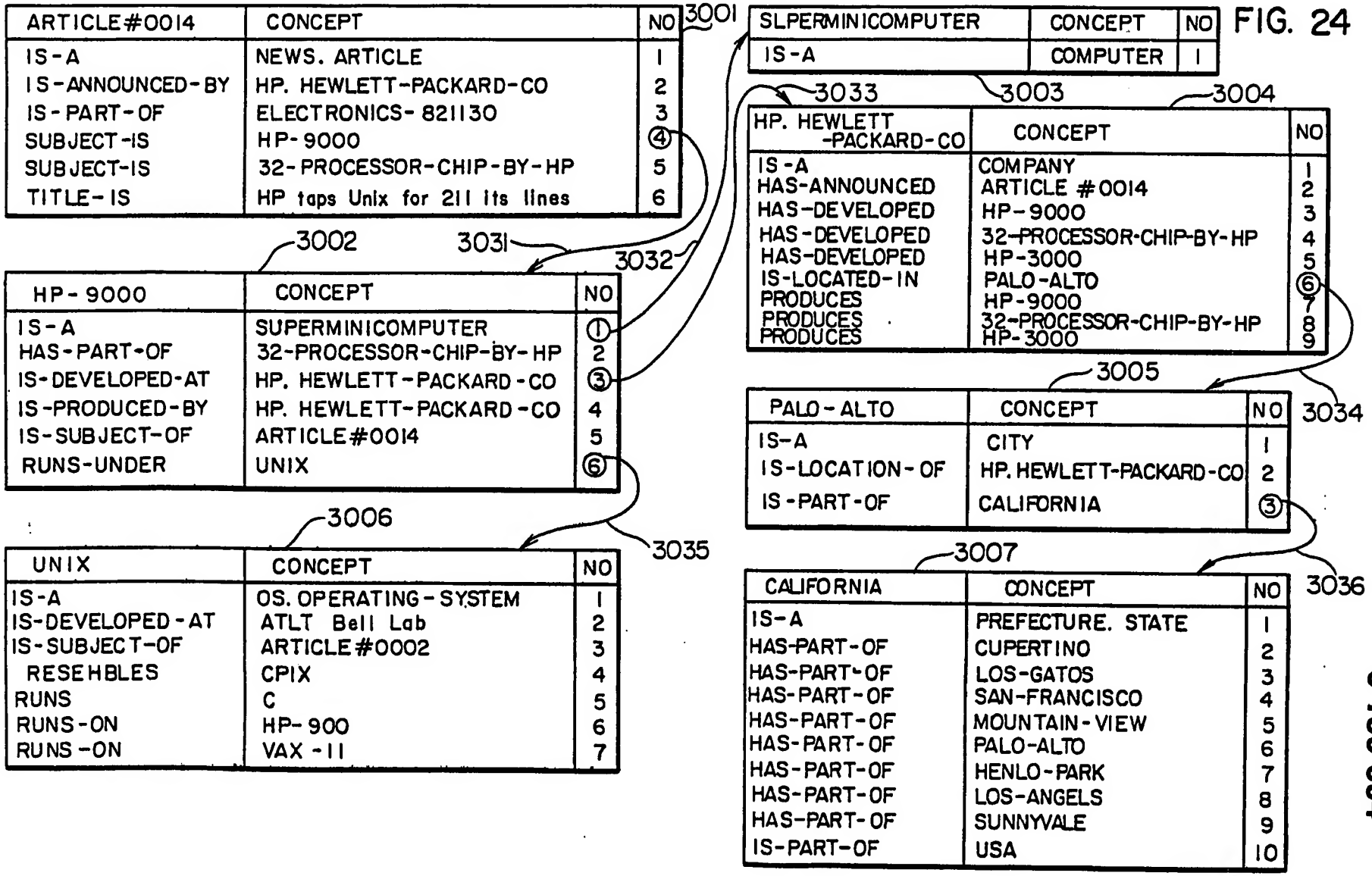


FIG. 24

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FIG. 25

NEWS. ARTICLE
BROWSE > tab *

NO	RELATIONSHIP
1	IS-ANNOUNCED-BY
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3	AUTHOR-IS
4	IS-PART-OF
5	SUBUJECT-IS
6	TITLE-IS

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NEWS. ARTICLE	TITLE-IS	SUBJECT-IS
ARTICLE#0001	All-optical. bidirectional local network	OB-LAN-0001
ARTICLE#1001	The coming surge in data-base systems	DBMS. DATABASE-HANAGEMENT-SYSTE M
ARTICLE#0002	Bell. DEC announce supprt for Unix	UNIX
ARTICLE#0003	New Apples might. compete head on	APPLE-LISA APPLE-MACINTOSH
ARTICLE#0004	Desktop OCR reads six fonts	TO-5000
ARTICLE#0005	Ethernet data link controller is single chip	THE-8001
ARTICLE#0006	Optical check reader speeds bank processing	SERIES-800
ARTICLE#0007	Graphic Station Can Stand Alone	METAPHOR-WORK-STATION
ARTICLE#0008	S-100 peripheral card converts text input into	CP-5100

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